

# INFORMATIONAL LEAFLET NO. 161

## PROCEEDINGS OF THE 1972 NORTHEAST PACIFIC PINK SALMON WORKSHOP

Edited by:

Jack E. Bailey  
Rapporteur - 1972 Pink Salmon Workshop  
National Marine Fisheries Service

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STATE OF ALASKA

WILLIAM A. EGAN - GOVERNOR

DEPARTMENT OF FISH AND GAME

SUBPORT BUILDING, JUNEAU 99801



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December 1972

# PROCEEDINGS OF THE 1972 NORTHEAST PACIFIC PINK SALMON WORKSHOP

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Jack E. Bailey  
Rapporteur - 1972 Pink Salmon Workshop  
National Marine Fisheries Service  
P. O. Box 155  
Auke Bay, Alaska 99821

## FOREWORD

The Northeast Pacific Pink Salmon Workshops have been held biennially since 1962. The purpose of the workshops is to encourage exchange of ideas, criticisms, questions and suggestions. It is the intent that participants and respective agencies will receive maximum benefit from the meetings through the continuous correspondence long after the adjournment of the workshop. To this end, we have liberally reproduced all material made available by the panel speakers. In addition, we have added one discussion which we believe is of interest to you who attended the workshop.

Panel topics were selected from a list of six suggested by the 1970 steering committee. For the first time since the inception of the workshops, two full panels were devoted to artificial propagation and multiple use of watersheds. That these topics are of major importance in the salmon industry is a matter of public record. Perhaps the 1974 steering committee will consider a full day devoted to environmental concerns.

We are at a threshold regarding workshops which is incisively discussed by Sheridan and Bishop in the critique. We cannot logically discuss, debate or criticize environmental problems with only biological inputs. The inclusion of other disciplines in future meetings is of paramount importance.

Whether the workshop continues to be a pink and "chum salmon affair" rests in the hands of the "74" steering committee. There was a strong feeling among the 1972 participants that a salmon workshop was more realistic.

Robert S. Roys  
Chairman, Steering Committee  
1972 Pink Salmon Workshop

Jack E. Bailey  
Rapporteur  
1972 Pink Salmon Workshop

## TABLE OF CONTENTS

	<u>Page</u>
Introduction (incl. Agenda) . . . . .	1
Talks by panel participants	
Panel I.    Research Needs of Management . . . . .	5
Pink salmon research needs in Alaska with emphasis on environmental types . . . . .	6
Review of pink salmon research needs of management in Prince William Sound as related to Alaska pipeline . . .	7
Panel II.    Factors of Sea Life . . . . .	21
Biological studies of the proposed Kiket Island nuclear power site . . . . .	22
A model of juvenile pink salmon growth in the estuary . .	25
Study of fingerling pink salmon at Kodiak Island with an evaluation of the method of forecasting based on townetting . . . . .	40
Panel III.   Artificial Propagation . . . . .	50
Evaluation of sockeye spawning channels . . . . .	51
Evaluation of Bams-box hatchery on Tsolum River pink salmon . . . . .	52
Historical review of evaluation of pink salmon spawning channels . . . . .	65
Evaluation of chum (and pink) channels . . . . .	66
Studies of the survival of downstream chum salmon fry released after feeding in a freshwater pond . . . . .	67
Progress report on chum salmon propagation in Oregon . .	77

## TABLE OF CONTENTS (Continued)

	<u>Page</u>
Some preliminary observations on possible indices of pink and chum salmon fry quality . . . . .	81
A summary of the spawning channel research by F.R.I. as related to the effects of gravel composition and spawner density on spawning success, emergence survival, and fry quality . . . . .	84
Effects of density on the spawning success of chum salmon ( <u>Oncorhynchus keta</u> ) - A progress report . . . . .	91
Saltwater and freshwater pond rearing of chum salmon . .	101
Panel IV. Multiple Use of Watersheds . . . . .	113
The short term physical effects of stream channelization at Big Beef Creek . . . . .	114
Carnation Creek watershed study . . . . .	117
Effects of forest harvesting on fishery -- all bad? . . . .	120
Using resource information in decision making on Southeast Alaska watersheds . . . . .	121
The safeguarding of future options - with particular emphasis on the prospects of irreversibility in environmental decision policy . . . . .	122
The necessity for a system approach in integrated watershed management . . . . .	125
Summation and Critique . . . . .	126
Addendum - World Pink Salmon Catch Statistics . . . . .	129
Appendix I. Roster of 1974 Steering Committee . . . . .	138
Appendix II. Response to Questionnaire . . . . .	139
Appendix III. List of Registrants . . . . .	142

# PROCEEDINGS OF THE 1972 NORTHEAST PACIFIC PINK SALMON WORKSHOP

## INTRODUCTION

The sixth Northeast Pacific Pink Salmon Workshop was held in the Centennial Building, Sitka, Alaska, on February 1, 2, and 3, 1972. About 92 people (fishery biologists, natural resource managers, students and administrators) attended (Appendix III).

Steering Committee members were:

Jack Bailey - NMFS\*  
(Rapporteur) - Auke Bay

Ray Johnson - WDF  
Olympia

Robert Bams - FRBC  
Nanaimo

Sigurd Olson - USFS  
Juneau

Thomas Bird - CFS  
Vancouver

Robert Roys - ADF&G  
Juneau

Alan Chapman - IPSFC  
Westminster

Richard Tyler - FRI  
Seattle

\* Agencies are identified in Appendix III.

Dr. Ryuhei Sato, an Assistant Professor from Tohoku University, Japan, was co-chairman of the Artificial Propagation Panel. He discussed Japanese experiments with river survival of migrant chum salmon fry and saltwater and freshwater pond rearing of chum salmon.

The panel topics, sub-topics and speakers are listed in the following agenda.

## AGENDA

Tuesday - 1 February

0900 - 1000: Registration - welcome - introduction

Bob Roys, Chairman, Steering Committee

1000 - 1200: Panel I - Research Needs of Management,  
Panel Leader, John Valentine, ADF&G

Pink Salmon Research Needs in Alaska with Emphasis on  
Environmental Types. Jack Lechner, ADF&G

Review of Pink Salmon Research Needs of Management in  
Prince William Sound as Related to the Alaska Pipeline.  
Steven Pennoyer, ADF&G

#### LUNCH

1330 - 1700: Panel II - Factors of Sea Life.  
Panel Leader, Richard Tyler, FRI

Biological Studies of the Proposed Kiket Island Nuclear Power  
Site. Jerry Stober, FRI

A Model of Juvenile Pink Salmon Growth in the Estuary. John  
Sibert, FRI, and R. R. Parker, FRBC

Study of Fingerling Pink Salmon at Kodiak Island with an  
Evaluation of the Method of Forecasting Based on  
Townnetting, Richard Tyler, FRI

Wednesday - 2 February

0900 - 1200: Panel III - Artificial Propagation.  
Panel Leader, R. S. Bams, FRBC

Evaluation of Sockeye Spawning Channels. Roger Kearns, CFS

Evaluation of Bams-box Hatchery on Tsolum River Pink Salmon.  
R. S. Bams, FRBC

Evaluation of Chum (and Pink) Spawning Channels. Fred Fraser,  
CFS

Historical Review and Evaluation of Pink Salmon Spawning  
Channels. Al Chapman, IPSFC

Progress Report on Washington Department of Fisheries  
Spawning Channel Operations. Ray Johnson, WDF

## LUNCH

1330 - 1700: Panel III (continued)

Studies of the Survival of Downstream Chum Salmon Fry Released After Feeding in a Freshwater Pond. Ryuhei Sato, Japan

Progress Report on Chum Salmon Propagation in Oregon. Bill McNeil, OSU

Some Preliminary Observations on Possible Indices of Pink and Chum Salmon Fry Quality. Presented for Derek Poon by Bill McNeil, OSU

A Summary of the Spawning Channel Research by FRI as Related to the Effects of Gravel Composition and Spawner Density on Spawning Success, Emergence Survival, and Fry Quality. K. Koski, FRI

Effects of Density on the Spawning Success of Chum Salmon (Oncorhynchus keta) - A Progress Report. Steve Shroder, FRI

Saltwater and Freshwater Pond Rearing of Chum Salmon. Ryuhei Sato, Japan

1900-2100: Banquet

Thursday - 3 February

0900-1200: Panel IV - Multiple Use of Watersheds.  
Panel Leader, Tom Bird, CFS, Vancouver

The Short Term Physical Effects of Stream Channelization at Big Beef Creek. Jeff Cedarholm, FRI

Carnation Creek Watershed Study. David Narver, FRBC

Effects of Forest Harvesting on Fishery--All Bad? Read by T.W. Chamberlin for Robert Willington, UBC

## LUNCH

1330-1700: Panel IV (continued)

Using Resource Information in Decision Making on Southeast

Alaska Watersheds. Joseph Zylinski, USFS

The Safeguarding of Future Options--with Particular Emphasis  
on the Prospects of Irreversibility in Environmental Decision  
Policy. Philip Meyer, CFS

The Necessity for a System Approach in Integrated Watershed  
Management. T.W. Chamberlin, CFS

PANEL I.

RESEARCH NEEDS OF MANAGEMENT

PANEL LEADER: John Valentine  
ADF&G, Ketchikan

No paper received.

PINK SALMON RESEARCH NEEDS IN ALASKA WITH EMPHASIS ON  
ENVIRONMENTAL TYPES

Westward Region Commercial Fisheries Division: Comments by Jack Lechner,  
Alaska Department of Fish and Game

- I. DETERMINATION OF PINK SALMON OPTIMUM ESCAPEMENT LEVELS,  
WITH EMPHASIS ON MAJOR PRODUCTION SYSTEMS: Kodiak Island  
Red River System.
- II. OPTIMUM TIMING FOR OBTAINMENT OF ESCAPEMENT GOALS
- III. STUDIES OF PINK SALMON SYSTEMS TO DETERMINE WINTER ENVIRON-  
MENTAL CONDITIONS
- IV. HABITAT ENHANCEMENT:
  - A. Stream degradation problems; Kodiak Island Buskin River
    - 1. Sewage pollution
    - 2. Sediment pollution
    - 3. Water temperature factors
  - B. Full utilization of spawning grounds blocked by natural barriers,  
with emphasis on systems which currently have established runs  
below barriers: Current programs as Kodiak Island Portage Bay  
and Seal Bay streams and potential Kodiak Island Baumans and  
Kiaugnak Bay stream systems.
  - C. Drift log jam removal of blocked pink salmon systems, which  
have been observed as past potential systems.
  - D. Feasibility of experimental introduction of odd-year pink returns  
into even-year systems: Kodiak Island Red River system.
- V. BETTER DISTRIBUTION OF PINK SALMON RETURNS THROUGH ARTIFICIALLY  
MOVING OF STOCKS FROM SYSTEMS RECEIVING EXCELLENT RETURNS TO  
A SYSTEM THAT DUE TO ENVIRONMENTAL CONDITIONS OF THE PARENT  
YEAR OR DURING THE RETURN YEAR PRECLUDED SUFFICIENT ESCAPEMENT  
TO MAINTAIN THE CYCLE.
- VI. INCREASED KNOWLEDGE OF THE ESTUARY SURVIVAL OF PINK SALMON FRY  
AND FINGERLING.

# REVIEW OF PINK SALMON RESEARCH NEEDS OF MANAGEMENT IN PRINCE WILLIAM SOUND AS RELATED TO ALASKA PIPELINE

Steven Pennoyer, Alaska Department of Fish and Game

## TRANS-ALASKA PIPELINE SYSTEM

### Project Description

The following project description is taken from a summary by the Alyeska Pipeline Service Company.

The Alyeska Pipeline Service Corporation has proposed to build a 48-inch steel pipeline stretching 789 miles from Prudhoe Bay to a tanker loading terminal in Valdez Arm to Prince William Sound.

The pipe itself is made of approximately half-inch steel. Sections are to be alternately buried or elevated, depending on specific location and permafrost conditions. At capacity, the line will carry two million barrels of crude oil per day passing through 12 pump stations remotely controlled from Valdez.

The design calls for installation of 29 electronically controlled block valves with a four minute closing time. These are operated either remotely from Valdez or locally by use of a gas engine. The line will incorporate 23 check valves preventing back flow of oil in case of a shutdown.

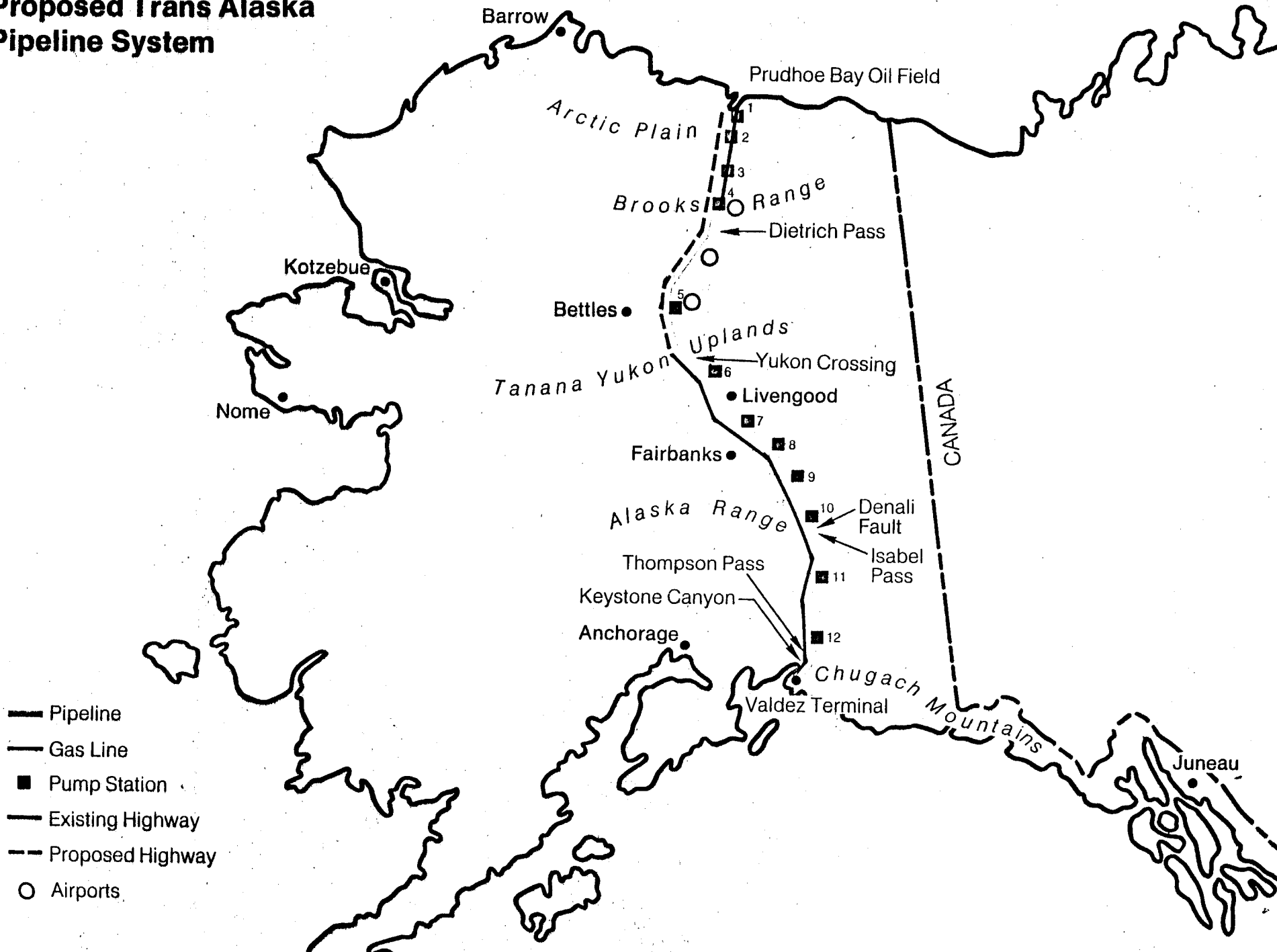
Oil received from the producers at the origin station will be at temperatures up to 145 degrees Fahrenheit. Oil will remain warm as it flows through the line due to hydraulic friction. To overcome the problem of thawing areas or permafrost supporting the pipe, special construction features have been incorporated.

Pipeline operation is expected to commence in three stages. In the initial stage of operation the system will have the capability to transport 600,000 barrels per day. The second phase is scheduled to be completed approximately two years after the initial startup. At this stage the system would have the capacity to transport 1,200,000 barrels of oil per day. The final phase is expected to be completed approximately seven years after the initial startup. At this time the system would reach its ultimate capacity of 2,000,000 barrels per day.

The proposed Valdez tanker terminal will be located on the southern shore of Port Valdez in the Jackson Point area. The terminal will cover an area of about 800 acres. Facilities will include storage tanks, docks, and tanker loading facilities; an operation control center; a ballast treatment system, and miscellaneous

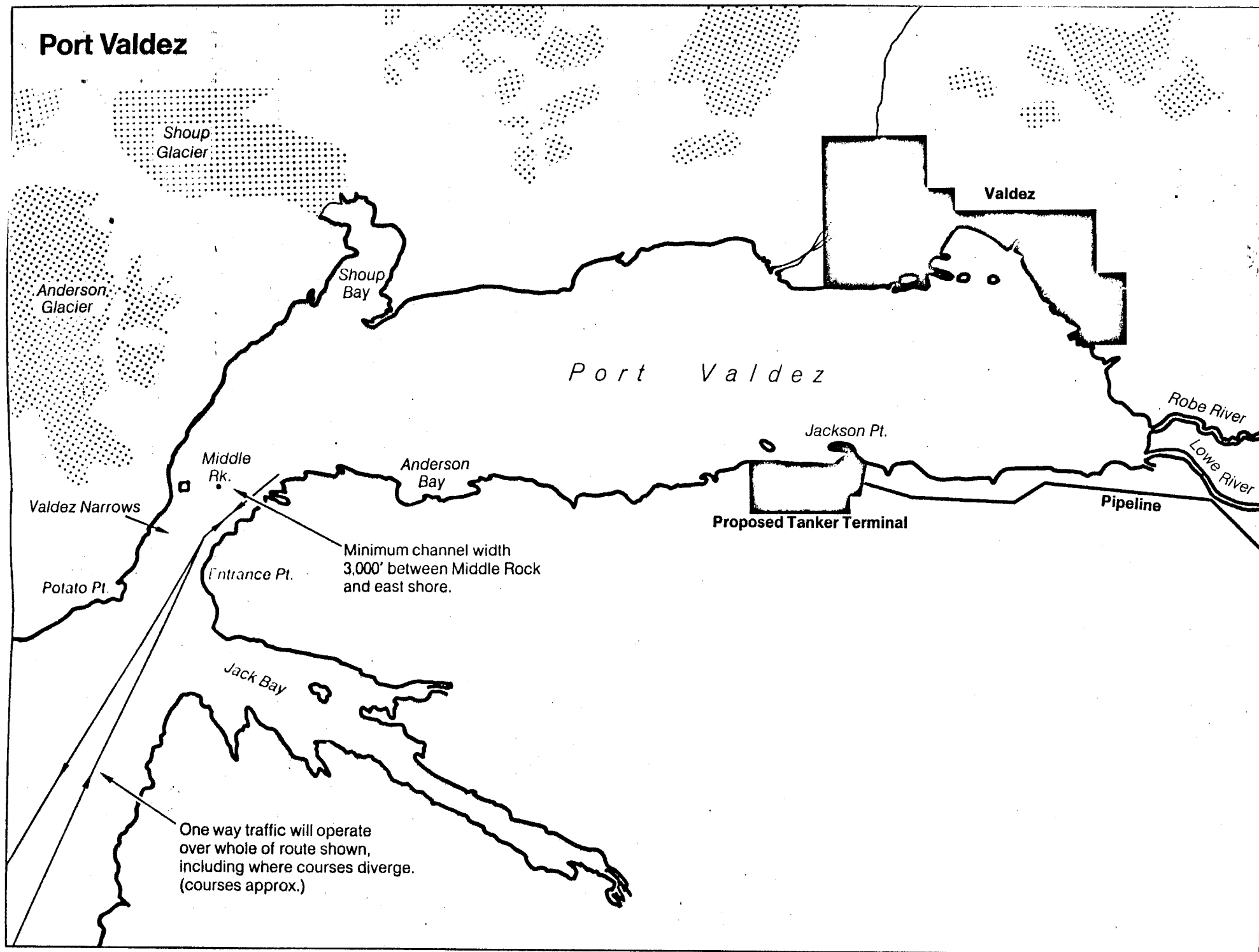
# Proposed Trans Alaska Pipeline System

- 8 -



From Alyeska Pipeline Service Company Project Description.

# Port Valdez



From Alyeska Pipeline Service Company Project Description.

pipeline administration structures. For the initial phase of operations up to 15-510,000 barrel storage tanks will be constructed. As the system capacity is increased, up to 44 tanks may be constructed should they be required.

The system will be built to handle up to 20 tankers a week varying in size from 16,000 to 250,000 deadweight tons.

Potentially five berths may be constructed. Tankers may be loaded at a rate of up to 80,000 barrels per hour at berth number one and up to 110,000 barrels per hour at all other berths. At the higher rate a 250,000 ton ship could be loaded in approximately one day.

Tankers arriving at Valdez will be carrying water ballast, some of which will be oil contaminated. This ballast will be transferred into water treatment facilities to remove the oily contaminants. The initial treatment facility will be able to treat within 48 hours the ballast discharge from the simultaneous arrival of one 120,000 and two 250,000 deadweight ton tankers. Initially three, and eventually five, 430,000 barrel capacity ballast storage tanks will be provided to contain the ballast. After the ballast is received from a ship it will be allowed to settle for a minimum of six hours in the storage tank. Floating oil is then removed by skimming devices and the remaining water is transferred by gravity through a chemically aided dissolved air flotation treatment unit. Effluent from the ballast treatment plant will contain less than ten parts per million of residual oil. This effluent will then be dispersed through jet orifices into the water of Port Valdez at a point approximately 100 feet below mean sea level.

Pilot services will be provided for all tankers entering or leaving Port Valdez. Tugs will be based for all tankers docking at the terminal. There will be separate inbound and outbound ship lanes starting at least 40 miles before the entrance to Prince William Sound, around the clock information service on all ship traffic in Valdez Arm and Port Valdez, rules requiring continuous communication between tankers and between tankers in the terminal facility, and two independent radar systems aboard each ship to provide backup in case of failure.

The one-way tanker traffic through Valdez Arm is supposed to reduce the risk of collisions between tankers. The narrowest portion of the entrance channel to the terminal is 3,000 feet at Middle Rock, which is quoted as being several times wider than ship channels in some other major cities.

Since the discussion is supposed to be oriented around pink salmon, we will largely ignore the contingency planning and program review being done on the balance of the pipeline. Alyeska, Alaska Department of Fish and Game,

the Bureau of Land Management and the Bureau of Sport Fish and Wildlife, are all conducting investigations on the pipeline route from Prudhoe Bay to Valdez. Studies are generally in a much more advanced state than those being carried out on the marine environment.

Contingency plans for potential oil spills from the terminal operation are rather elaborate. They include dikes surrounding storage tanks, all manners of inspection, interlocks and valve configurations to shut off any loading operation, quick disconnect couplings to remove tankers from their berths in case of emergency, earthquake stressed construction, location of the tanker farm above tsunami levels, the ability to seal off Valdez Arm or any part of it with booms, and all manner of skimming, absorbent, and cleanup devices. Presumably the sealing off of Valdez Arm would be a last step in the event of a large spill, but supposedly would prevent oil from entering Prince William Sound, directly.

Contingency plans for oil spills in Prince William Sound itself are not as well spelled out, but are supposed to be identified in the final contingency plan. Essentially they just seem to consist of utilizing the same methods and equipment used in Valdez Arm with the addition of sea going tugs from Port Valdez and possible help from the Coast Guard.

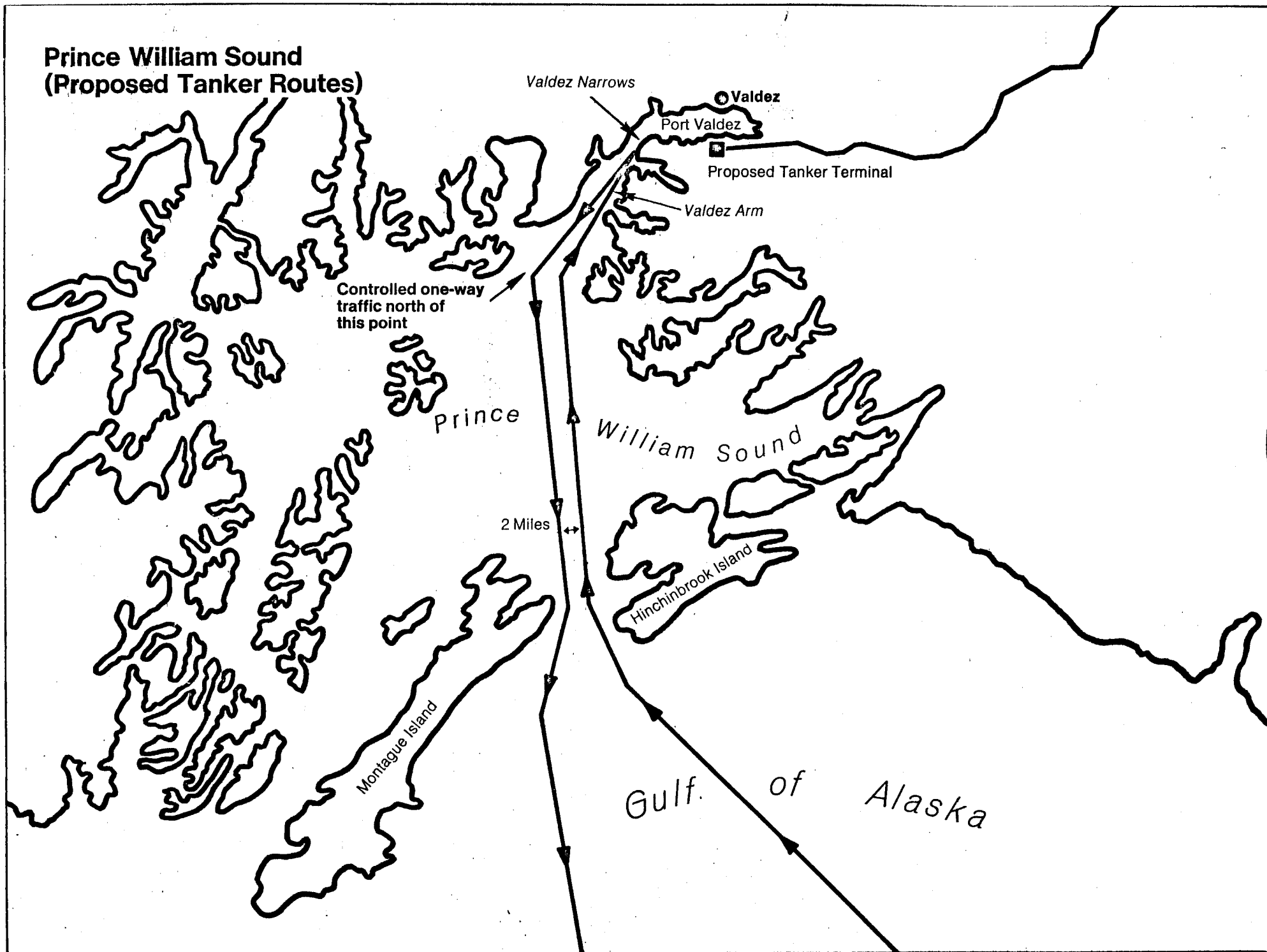
Essentially, then, this is a description of the pipeline terminal operation and the plans by Alyeska. Now, where do we stand in the evaluation of this project--what is the status of the various permits required to construct it, what studies are being done to evaluate the effect of it, and what seems to be the end-point of all these studies?

#### Permits Required

The impact statement preparation material for the issuance of the pipeline permit is in Washington, D.C. and is currently being compiled and written. The statement will probably not be out until the latter part of February, and at that time will be sent to the Council of Environmental Quality in the Executive Office. These people have 30 days to review it. At that time they would issue a recommendation as to whether the pipeline permit should be issued or not. If it is to be issued, it would be issued by the Interior Department and would then probably go immediately to court. Either Interior or the court may issue the permit with constraints such as additional studies, continuation of present studies, monitoring, etc. In the original stipulations on the pipeline permit are provisions for monitoring and modification during construction even after the permit is issued.

The State is still somewhat confused about the relationship between the pipeline permit impact statement, the terminal operation, and provisions for

**Prince William Sound  
(Proposed Tanker Routes)**



From Alyeska Pipeline Service Company Project Description.

contingency planning for Prince William Sound. The contingency plan for oil spills in the Sound is part of the permit request, according to information from National Marine Fisheries Service; however, these apparently apply mostly to the terminal operations and the question of how far into the Sound Alyeska is responsible has not been decided.

In deference to the objections in the initial hearings a large part of the present impact statement is related to the marine impact of tanker traffic into Valdez Terminal. Primarily this is a description of the resource and a review of the literature. Where possible inferences have been drawn as to potential effect of oil transport on these resources.

The National Contingency Plan of the U.S. Coast Guard requires contingency planning for transport of potentially detrimental or dangerous materials in the waters of the country. Apparently Alyeska will be required to submit their contingency plan 180 days in advance of startup. The contingency plan states how pollution would be cleaned up, not how prevented. Action by the courts or in the permit may elaborate on this.

A separate problem entirely is the issuance by the U.S. Forest Service and the Corps of Engineers of permits for the construction and operation of the tanker terminal. The U.S. Forest Service will issue permits for the Valdez Terminal in three parts. The first of these parts has already been issued, and allowed the Alyeska Corporation to clear and grade the site and design the facility. Part Two of the permit requires that Alyeska cannot start actual construction of the facility until the pipeline permit has been issued and until letters of non-objection are received from the Alaska Department of Fish and Game, the U.S. Fish and Wildlife Service, National Marine Fisheries Service, Environmental Protection Agency and Alaska Department of Environmental Conservation, etc. This part covers the upland section of the terminus only. Part Three, covering the water part of the terminus--this means loading facilities, ballast discharge, etc., requires a Corps of Engineers permit. The Corps of Engineers in turn requires certification from the State on the discharge. Present State water quality codes require zero discharge of oil into the waters of the State; however this is presently being interpreted as being zero visible discharge which means somewhere around 10 parts per million of oil.

The State will probably hold off on letters of non-objection to Phase Two of the terminal construction until the final impact statements can be reviewed. Phase Two likewise will have to await approval until State water quality discharge hearings can be held (public hearings) on the discharge plans as outlined in the impact statement. It is probable that these hearings would not be held until completion of studies presently being carried out by Alyeska in Prince William Sound on the effects of such discharge. It seems likely, therefore, that it will be at least a year until these hearings can be held.

The criteria for the letters of non-objection for Phase Two of the terminal permit are not defined very well by the various agencies. The National Marine Fisheries Service letter will probably hinge on the demonstration that "significant" deleterious effects to the environment and biota do not occur at the 10 parts per million discharge.

Continuation of monitoring studies is suggested in stipulations for the pipeline, but it has not been determined whether these stipulations apply to the terminal as well. This apparently is a legal question and is being studied by the Bureau of Land Management, the primary agency responsible for monitoring the pipeline. Actually, the permit for the construction of Phase Three of the terminal may have this type of stipulation built into it. Apparently the Environmental Protection Agency and the Corps of Engineers permit for the Cherry Point terminal in Puget Sound required extensive monitoring and continuing studies on the project.

#### Evaluation Studies

An interagency Fish and Wildlife Team was formed in 1970 to coordinate the research efforts of various agencies involved with the pipeline; however, it wasn't until April 1971 that the executive committee for pipeline matters, composed of the heads of the various agencies, formalized the creation of a marine section to cover terminal and marine operations related to the pipeline. Studies and informal meetings between various involved agencies had started in the fall of 1970.

The primary groups with ongoing studies related to the terminal or tanker operation are:

The Institute of Marine Sciences, University of Alaska  
and

Battelle Pacific Northwest Laboratories,  
both under contract to the Alyeska Pipeline Service Company,

The College of Biological Science, University of Alaska, funded by EPA,  
The National Marine Fisheries Service, Auke Bay Biological Laboratory,  
The U. S. Geological Survey,  
The U. S. Forest Service,  
and

The Alaska Department of Fish and Game.

These studies have primarily centered around physical and biological oceanographic studies in Valdez Arm itself. The main emphasis has been on the

possible effects of the ballast treatment plant discharge. Studies include current and wind patterns, background and baseline studies on intertidal biota, planktonic and fish populations in Valdez Arm, the salmon spawning areas, and several bioassay experiments.

The bioassay experiments particularly would have application elsewhere than Valdez Arm. Some are being conducted by Battelle Pacific Northwest Laboratories in a field laboratory at Valdez. They are conducting bioassays with indigenous species to determine the potential effects of chronic low level pollution from the ballast treatment discharge. The effects of chronic exposure on bioassay test species will be carried out for periods of 12 to 16 weeks and special attention will be given to chronic exposure of salmon eggs and sac fry.

The National Marine Fisheries Service is carrying out bioassay tests at its Auke Bay Biological Laboratory. They are specifically trying 1) to develop rapid bioassay techniques using Prudhoe Bay crude oil and immature forms of locally important marine organisms, 2) to develop capabilities to do long term chronic bioassays using locally important marine organisms and Prudhoe Bay crude oil, and 3) to develop the capability to use gas chromatography to monitor natural biogenic and petroleum hydrocarbons in tissues of marine organisms. The principal emphasis is initially in developing laboratory techniques to maintain and test Alaska organisms. The hydrocarbon analysis of experimental organisms is going to be conducted at the Seattle Biological Laboratory.

The College of Biological Sciences, University of Alaska, is carrying out bioassay work on the effect of Prudhoe Bay crude oil on coho salmon. These studies are continuing.

The U.S. Forest Service in cooperation with the Alaska Department of Fish and Game, Sport and Commercial Fisheries divisions, is carrying out a recreational resources survey of Prince William Sound. Certain areas of the Sound have been proposed as wilderness areas, and additionally, the Forest Service is interested in developing the recreational potential of Prince William Sound. These studies are not directly related to the tanker terminal or potential oil problems, but certainly the results will add to the background of knowledge necessary to evaluate potential or future problems concerning oil pollution.

Alaska Department of Fish and Game studies have not been directly related to the pipeline; however, our long term and rather extensive monitoring of pink and chum salmon populations in Prince William Sound will form some of the only presently available background data on these important species for the Sound as a whole. Unfortunately, at the present time no additional funding has been made available to beef up those studies for specific evaluation of potential oil pollution problems.

The question as to whether all of these studies will be continued past the issuance of a permit for the pipeline and the terminus is in some cases still not determined. It will probably depend on the final issuance form of the permit itself and any additional stipulations tacked on by the courts. It is probable that the funds currently being made available from the Interior Department to the National Marine Fisheries Service will expire as soon as the permit is issued; however, National Marine Fisheries Service people inform me that they are giving environmental projects a high priority. They are budgeting specifically for their own funds to carry on some of the programs in the Sound. These would include the baseline studies of intertidal biota, and the bioassay studies. They additionally are planning on having a team standing by for on-site inspections of any spills that occur. The action of oil from a spill and what parts of the environment it will enter are going to be quite difficult to determine if either the lab or from field studies except on an actual spill.

Additionally, it has been proposed through a subcommittee of the Fisheries Marine Section team that oceanographic studies on currents and winds be carried out in Prince William Sound to evaluate the contingency planning in case of a major tanker spill. Again, this has not received any funding.

The University of Alaska has proposed a multi-stage study for all of Prince William Sound. The study would try to tie together all of the factors of oceanography and biology in the Sound into one package that could be used for evaluating problems related to oil or anything else. Studies would include estimates of numbers of commercially and recreationally important fish and shellfish.

The proposed study is broken down into two sections, the first of which is a baseline study of inventorial and distributional data that would last from 24 to 36 months, cost estimated at approximately one and one-half million dollars per year. The second phase is a three to six year monitoring program that would cost five to seven hundred thousand dollars per year. No funding is presently available.

The National Marine Fisheries Service has addressed itself to the total picture in the Sound by proposing an operational plan for a simulation model of the oceanography of Prince William Sound as a whole.

#### Summary - Status of Knowledge

In summary, the permit for pipeline construction still rests in Interior awaiting review of the pipeline impact statement. It seems probable that this

impact statement will reach the Council on Environmental Quality by the end of this month. They will then have 30 days to review it and conceivably their recommendation could be returned to Interior early this spring. From there it does not seem possible to state at this time how fast Interior will move on the permit or how quickly the courts (if it does go to court) will settle the question of permit issuance.

The terminal operation will require a separate permit and judging from the progress of studies on the effect of ballast waste discharge and the State requirements for water quality discharge hearings, this would be at least a year off. Of course, it will take approximately three years to construct the pipeline, so all the ramifications of the terminal operation presumably would not have to be finalized immediately.

Where then, do we stand in our knowledge of the potential effects of this project on the marine ecosystem, including pink salmon, and what possible areas of investigation are still required? In this section I am drawing freely from personal conversations with various agency representatives, my own experience in Prince William Sound and on the Marine Section of the Interagency Fish and Wildlife Team and the preliminary impact statement prepared by the National Marine Fisheries Service.

The tanker routes, of course, will pass through ocean and coastal zone habitats from the Gulf of Alaska to Southern California or farther. It is not possible to accurately predict the effect of tanker oil traffic on this diverse number of habitats. Possible areas of pollution include: spillage during cargo transfer marine terminal operations, discharge of ballast water treatment effluent from marine terminal, discharge of oil contaminated ballast water from tankers on the high seas, tanker accidents while under way including grounding and collision, and failures of the pipeline systems which spill oil onto water courses leading to the sea.

Regulation of tanker traffic on the high seas is still the topic of international discussion. The United States has taken the position that we wish to halt all international discharge of oil and oily wastes into the oceans. This desire, however, is very difficult to regulate. Alaska state law will require that no ship will be loaded at Port Valdez unless the master of the vessel certifies that oily material has not been discharged at any point during the incoming voyage. Context of the regulation, however, permits discharges outside of State waters that are not in excess of 50 parts per million of oil residue.

The most dramatic effects of oil transportation may be visible in Prince William Sound. That also is where the bulk of the studies are now occurring and is within our range of experience, whereas the coastal zone to the south

and terminal problems in Puget Sound and California are not. Most of these comments on the need for research will therefore be confined to the Sound. As mentioned above international control of oil traffic is and should be the subject of continuing discussions.

Less dramatic than large oil spills, but perhaps more important, is the level of chronic oil pollution in Port Valdez from terminal and tanker operations. Current estimates on the amount of this chronic pollution from transfer operations, spillages, and predictions of the oil content of the treated ballast effluent, range from about 11 to 16 barrels of oil per day. Sufficient data on the oceanography of Port Valdez are not yet available to accurately predict diffusion and distribution of hydrocarbons discharged from the terminal operation. Present data does not allow accurate assessment of the degree of loss in primary productivity, production of benthic organisms, production of salmon, and the ultimate recreational and commercial utilization of resources in Port Valdez due to low level chronic pollution. Most of the studies now underway are directed toward this question, but as yet have not made significant progress, nor has the question of what is an acceptable degree of loss been tackled.

At this stage we cannot predict the likelihood of a major tanker accident in Prince William Sound, either through collision or grounding. This possibility, of course, should be realized and studies relating the possible fate of the oil from such a spill, probable degree of ability to clean the spill up, and the effects on various organisms in the Sound depending on the direction the oil took from the spill site, should be assessed.

From a pink salmon standpoint in the Eastern District of Prince William Sound, which includes Valdez Arm is estimated to produce somewhere around one-third of the salmon taken from the Sound commercially. As much as 90% of the even-year run of pink salmon in these areas spawn intertidally. They would therefore be directly exposed to any marine oil pollution.

One of the major herring producing areas of the Sound is in the Tatitlek Narrows just outside of Valdez Arm. This population would be especially susceptible to any oil discharge.

#### Needed Research

Reverting to the title of the panel, what are the management needs of research involved with this pipeline project? Again, I am largely restricting my comments to Prince William Sound, although certainly the studies done there would be applicable elsewhere. Certainly one of the most obvious things that needs to be done is extend the general scope of the studies to include all

of Prince William Sound, not just Valdez Arm. As far as tanker spills in the outer Sound are concerned, State and Federal review agencies need to get early participation in the definition of objectives and criteria for the pollution control and cleanup plans.

Secondly, the Department strongly feels that assessment of the magnitude and composition of commercial and recreationally important species in Prince William Sound is needed. Further work on pink salmon would be desirable, but knowledge of shellfish, herring, etc., is very fragmentary. Knowledge of what is present should be coupled with an economic study of the present and potential value of these resources.

In the case of a spill or damage from terminal or tanker operation the Federal Government would send in a damage assessment group. This group would try to determine the extent and nature of the damage from the spill. All work is done with possible future court action in mind by either the Federal Government, State or individuals against the responsible group; however, complete assessment of damage is very difficult without prior baseline studies to determine population composition and magnitudes prior to the spill.

From the standpoint of needed specific studies I think it can be fairly stated that:

1. The studies presently started on oceanography, biological baseline work and bioassays, should be followed to a logical endpoint. The bioassay work should be expanded to assess not only effects of Prudhoe Bay crude oil, but the effects of other materials likely to be in tanker ballast water. This would primarily involve crude from other areas, but could also include other materials these tankers may transport on other trips. The possible content of the ballast water itself, depending on what body of water it is taken from, should be investigated.
2. Baseline studies should be extended to include important areas of Prince William Sound itself. Areas of potential high risk, should be identified in the Sound and appropriate baseline studies done on them to evaluate the importance of protecting them in relation to contingency plans developed to handle possible oil spills. Such things as the presence of larval shellfish, rearing areas for juvenile shellfish, and possibly an increase in pink and chum salmon distributional monitoring should be considered.

3. Oceanographic studies should definitely be extended out into Prince William Sound to develop contingency planning.

In conclusion, studies required to evaluate the effect of tanker-terminal operation on Prince William Sound and Valdez Arm are either at a very preliminary stage or are as yet unfunded. Under the present permit setup it is quite possible for us to end up with an approved pipeline before these studies are completed and a permit is issued for terminal operation. Of course, there will be a construction grace period before operations start of some three years, but the question may be how to make terminal-tanker operations compatible with the environment not whether it can be made safe. All of this is conjecture at this point until we can review the final impact statement and see what stipulations may have been added to it by Interior or the courts.

PANEL II.

FACTORS OF SEA LIFE

PANEL LEADER: Richard Tyler  
FRI, Seattle

# BIOLOGICAL STUDIES OF THE PROPOSED KIKET ISLAND NUCLEAR POWER SITE<sup>1/</sup>

O. J. Stober, Fisheries Research Institute

## ABSTRACT

The Fisheries Research Institute has investigated the fisheries of Skagit Bay and the marine ecology in the vicinity of Kiket Island since 1969 for determination of the potential impact of construction and operation of a nuclear power station. Kiket Island, located in Northern Skagit Bay east of Deception Pass, Skagit County, Washington, is the proposed site for a steam electric station by Seattle City Light and Snohomish County P.U.D.

The objectives of the continuing studies were set according to problems specific to this site, as follows: juvenile salmonid emigration, thermal effects, intertidal ecology, subtidal ecology, benthic fish abundance and diversity, pelagic egg and larval fish abundance, aquaculture directed toward eventual beneficial uses of heat, and investigations of an intake filter system designed to exclude small fish from the cooling water. The literature concerning juvenile fish escape velocities and marine biofouling was reviewed. Progress to date is detailed in the First and Second Annual Reports.

Tow net sampling was conducted in Northern Skagit and Similk bays from March 24 through May 28, 1971, augmented by beach seine sampling and visual beach surveys of the fish schooled near shore. Temporal and spatial movements and the horizontal and vertical relative abundance of juvenile chum salmon were determined. A comparison with the results of the pink salmon emigration determined during 1970 showed that whereas pink and chum salmon both tended to school in dense numbers inshore, the chum salmon occurred in approximately equal numbers offshore. The vertical distribution of chum salmon catch over the entire season of 1971 was determined as follows: 87% were caught at the surface, 10% at 30 feet, and 3% at 60 feet. A comparison of daytime and nighttime adjusted chum salmon catches indicated a decrease in the surface catch at night but also an increase in catches at 30 and 60 feet. This finding suggests that with the onset of darkness, juvenile chum salmon descend to greater depths. The tow net catch of juveniles salmonids and of other pelagic fish was consistently higher in Similk Bay during both seasons.

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<sup>1/</sup> Supported by Snohomish County P.U.D. and Seattle City Light.

Investigations of thermal effects were continued in the on-site laboratory. Thermal resistance studies were conducted on pink, chum and chinook salmon for determination of equilibrium loss and death times at acute lethal temperatures. Acute lethal temperatures ranged from 23 to 30 C, whereas the ambient temperature averaged 10 C. In order of increasing thermal resistance are pink, chum and chinook salmon. Equilibrium loss significantly preceded death at acute temperature. Such an effect has ecological significance in a predation situation. In most instances, we found thermal tolerance to be greater than 10 C above the ambient water temperature, which is the  $\Delta t$  proposed for this steam electric station. Therefore, we conducted predation experiments to assess potential sublethal thermal effects at temperatures ranging from ambient temperatures to lower lethal temperatures to measure relative ability to evade predators in thermally stressed and control prey. Sublethal thermal effects were not likely with chum salmon and did not occur in chinook salmon at temperatures below 21.5 C.

The cooling water effluent, when released into the Bay, will create a thermal gradient emanating from the point of discharge. The behavioral response of juvenile salmonids of these three species was investigated in a horizontal moving thermal gradient for the purpose of obtaining predictive information on the ability of salmon to detect, choose, or avoid various temperatures. Chum salmon strongly avoided 15 to 16 C, and very few chum salmon frequented temperatures greater than 17 C. The minimum measurable temperature increase above ambient that could be detected and responded to by chum salmon was from 0.25 to 0.75 C. In addition, thermal resistance tests from 25 to 28 C were conducted on fish of six benthic species. These were, listed in order of increasing thermal tolerance, Pacific snakeblenny, rock sole, English sole, butter sole, sand sole, and starry flounder. Dynamic seasonal acclimation to ambient temperature and salinity was demonstrated for Dungeness crab. Thermal resistance to acute lethal temperatures was determined from 25 to 27 C.

Studies of the intertidal ecology have shown the average densities of important clams with confidence limits for the intertidal areas surrounding Kiket Island. These data may be used in prediction of direct damage to the recreational and commercially valuable clam stocks from construction in the intertidal. The subtidal studies were designed to reveal the temporal and spatial differences in the abundance of Dungeness crab, the interrelationships of crabs with the benthic infauna and with the thermal relationships of selected species of the benthic community. Crab catch was positively correlated with temperature during the months of April, May and June but seemed to match more closely the salinities during the winter months of November, December and January when it declined in the shallow areas. Migration studies of tagged and recaptured crabs indicated two relatively distinct populations, one in Similk Bay and the other ranging south of Kiket Island as far as Camano Island.

Benthic fish were sampled on shelf areas and at midchannel bottom areas, and species diversity indices were calculated. The shelf trawls showed a strong seasonal decline in numbers and species during March and April. This trend was less evident at the midchannel stations. A migration of fish off the shelf areas into the deep areas during the spring was evident. This occurred during a period when temperatures and salinities were lowest, and large fluctuations in salinity were common. The deepest midchannel stations had the most consistent diversity indices.

The most critical problem posed by the once-through method of cooling has been identified in placement and design of the cooling water intake structure. Pink and chum salmon are most vulnerable because of their small size while in the vicinity of the Island, and there are no screening techniques presently available to prevent passage through the cooling system. Tests have been made of the feasibility of a submarine filter system at the site that shows promise in the exclusion of small fish and the larger invertebrates. Biofouling is being investigated in relation to submarine filter systems.

## A MODEL OF JUVENILE PINK SALMON GROWTH IN THE ESTUARY

John Sibert, Fisheries Research Institute and R. R. Parker,  
Fisheries Research Board of Canada

This model was constructed in an attempt to bring together in a quantitative way a number of heretofore unrelated observations and measurements on the life history, feeding and growth of two species of salmon. The model simulates the growth of a population of pink salmon fry under predation by a population of growing coho salmon fry during the first two months of sea life. A very simple predation model is used where the predator will strike at all potential prey but will only actually kill and eat those which are smaller than some maximum size. This maximum size as well as the maximum daily ration are fixed proportions of the predator's body weight. Features included in the model which can be modified to simulate different situations are: (1) "head start", the numbers of days by which the peak of the pink downstream migration preceeds that of the coho, (2) mean length at entry of both populations, (3) growth rate of both populations, (4) length-weight relationships, (5) maximum prey size and maximum daily ration, (6) number of "hits" made by the predator before resorting to an (assumed adequate) alternate food. The numerical values as input for a "standard run" on the computer are given in the table along with some references to the literature. The figures show an outline of the logic of the model and some representative results. A more complete description of this model is in preparation.

### Captions for Figures

- Figure 1. Distribution in time of numbers of fry entering the estuary. Illustrates a situation with a "head start" of five days.
- Figure 2. Outline of logical steps in the simulation.
- Figure 3. Time course of simulation showing the change in numbers of fry. Illustrates the situation with and without predators present.
- Figure 4. Time course of the simulation showing the change in the length frequency distribution of the prey population. The outer boundary of the histograms represents the length frequency distribution of the population without predation; the inner boundary represents the situation with predation. It is apparent that the smaller size fraction is being culled from the population. This size selection

is reflected in the growth rate. The solid line represents the change in the mean length of the population without predation; the dashed line represents the change in mean length with predation. This result suggests that caution should be exercised in interpreting field estimates of growth rate.

- Figure 5. The time course of two "standard runs" using different random number series. The numbers on the graph indicate the day of simulation. This graph can be divided into four sections: (1) first 12 days where the number of prey is small and the predators eat all prey, (2) day 13 to 25 where the prey are growing and fewer are needed to meet the maximum daily ration of the predator, (3) day 26 to 35 where the downstream migration of prey has ceased and the number of prey per predator is decreasing due to predation, (4) day 36 to 55 where the prey are becoming too large to be eaten and the number of prey eaten per predator decreases to zero.
- Figure 6. The time course of the daily prey mortality. It falls rapidly to a value of about 2% per day. The area in the box indicates the range of values measured by two stage marking and recapture experiments at Bella Coola in 1963, 1964 and 1965. (Parker, 1968).
- Figure 7. Effect of increasing the size of the prey population relative to the predator population. The number of prey eaten in the duration of the simulation follows a well known hyperbolic relationship (Holling, 1959, 1965; Ivlev, 1961).
- Figure 8. Effect of increasing the "persistence" of the predator on numbers of prey eaten. The number of "hits" is the number of attempts made by a predator to find a suitable size prey before resorting to an alternate food source.
- Figure 9. Effect of prey growth rate on the number of prey eaten out of a total population of 100,000 prey. Emphasizes the importance of maintaining a high growth rate.
- Figure 10. Effect of "head start" time on numbers of prey eaten out of a population of 100,000. It is obvious that the relative timing of the migrations is very important. Delaying the release of coho from a hatchery to spare the pink population would also increase the size of the coho entering the estuary. The four curves are for coho of mean lengths of 11.0, 11.3, 11.7 and 12.2 cm. In spite of the increase in length, the savings of pink fry produced by a 15 day delay is considerable.

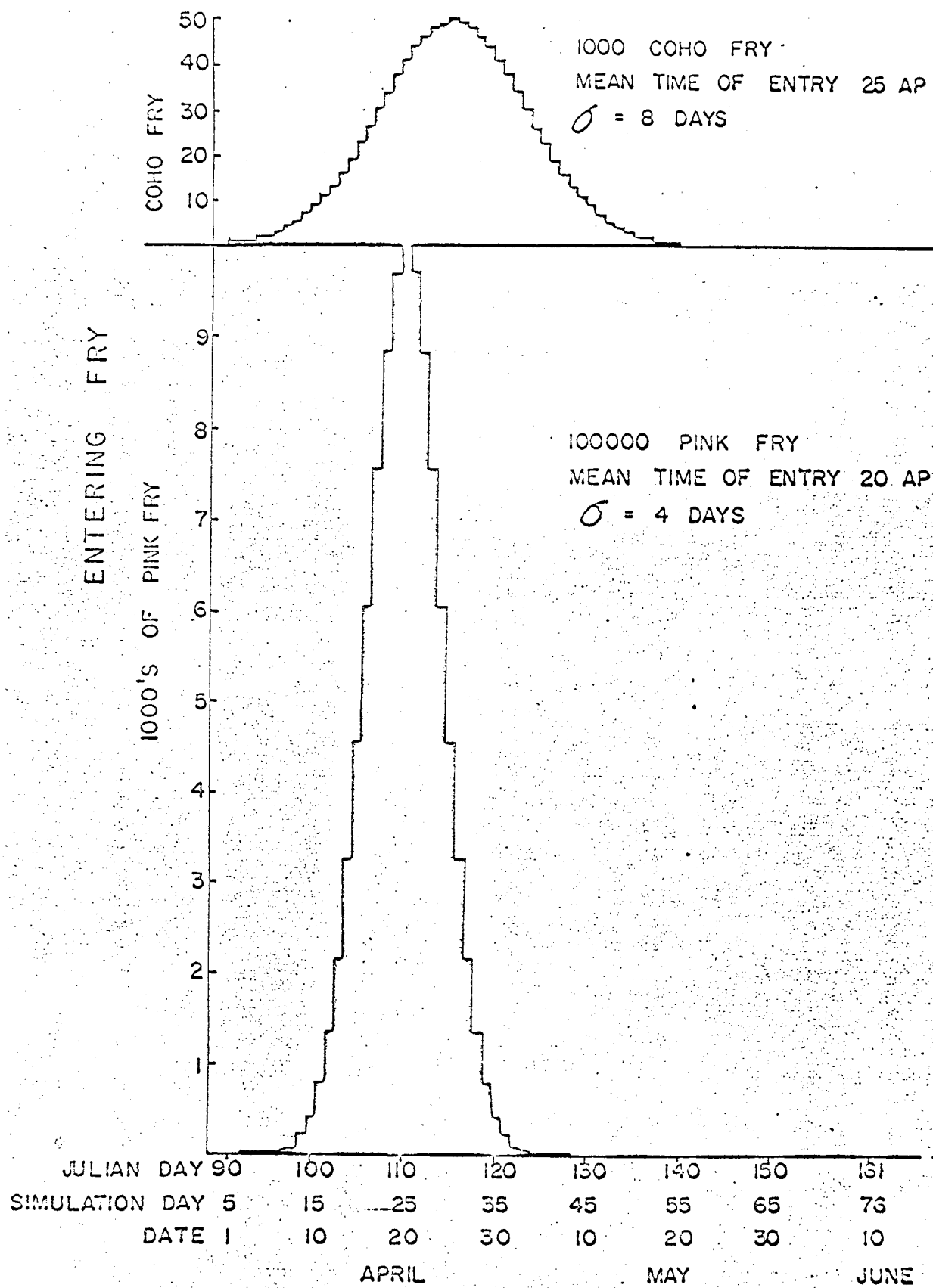


Figure 1.

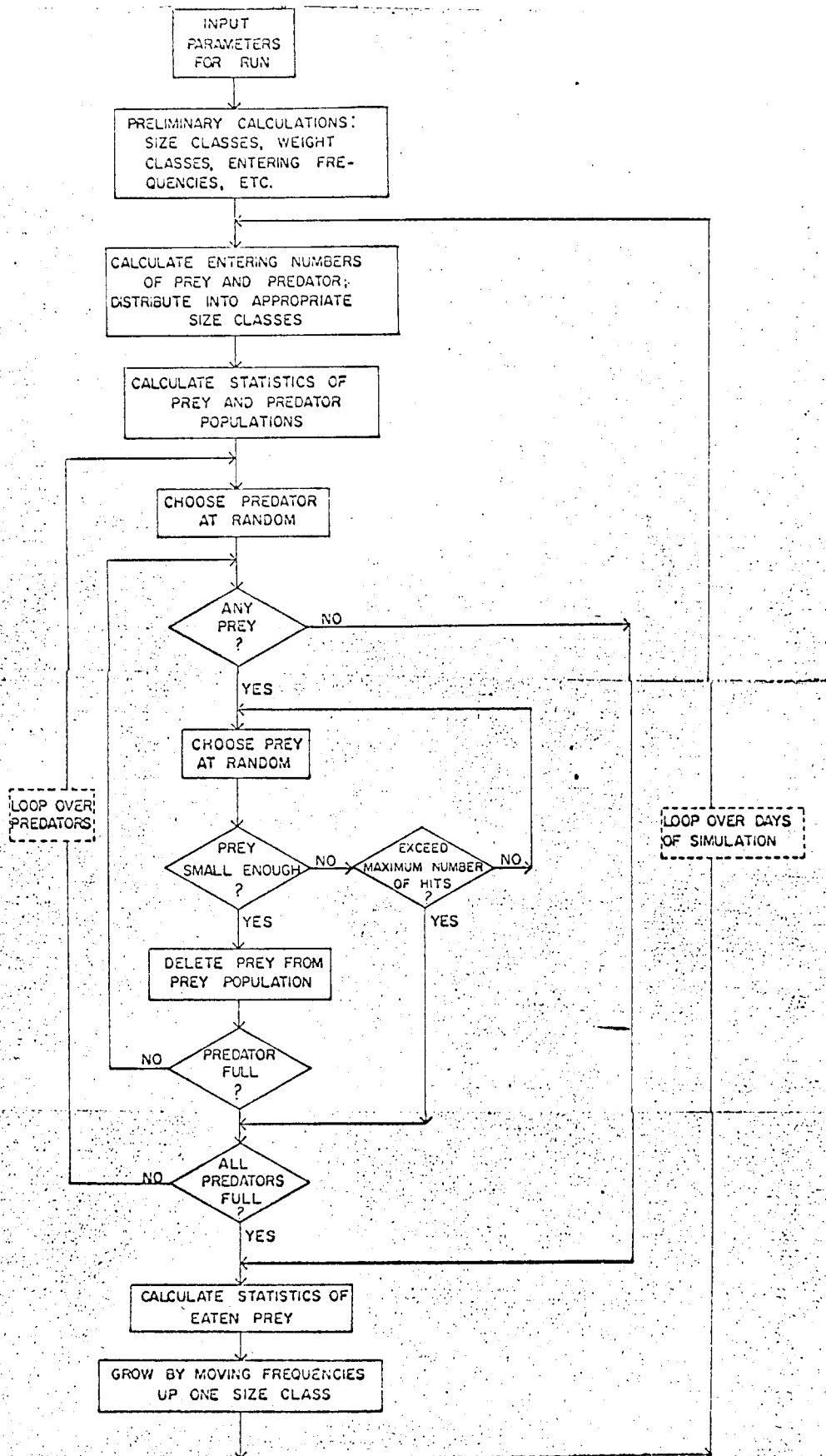


Figure 2.

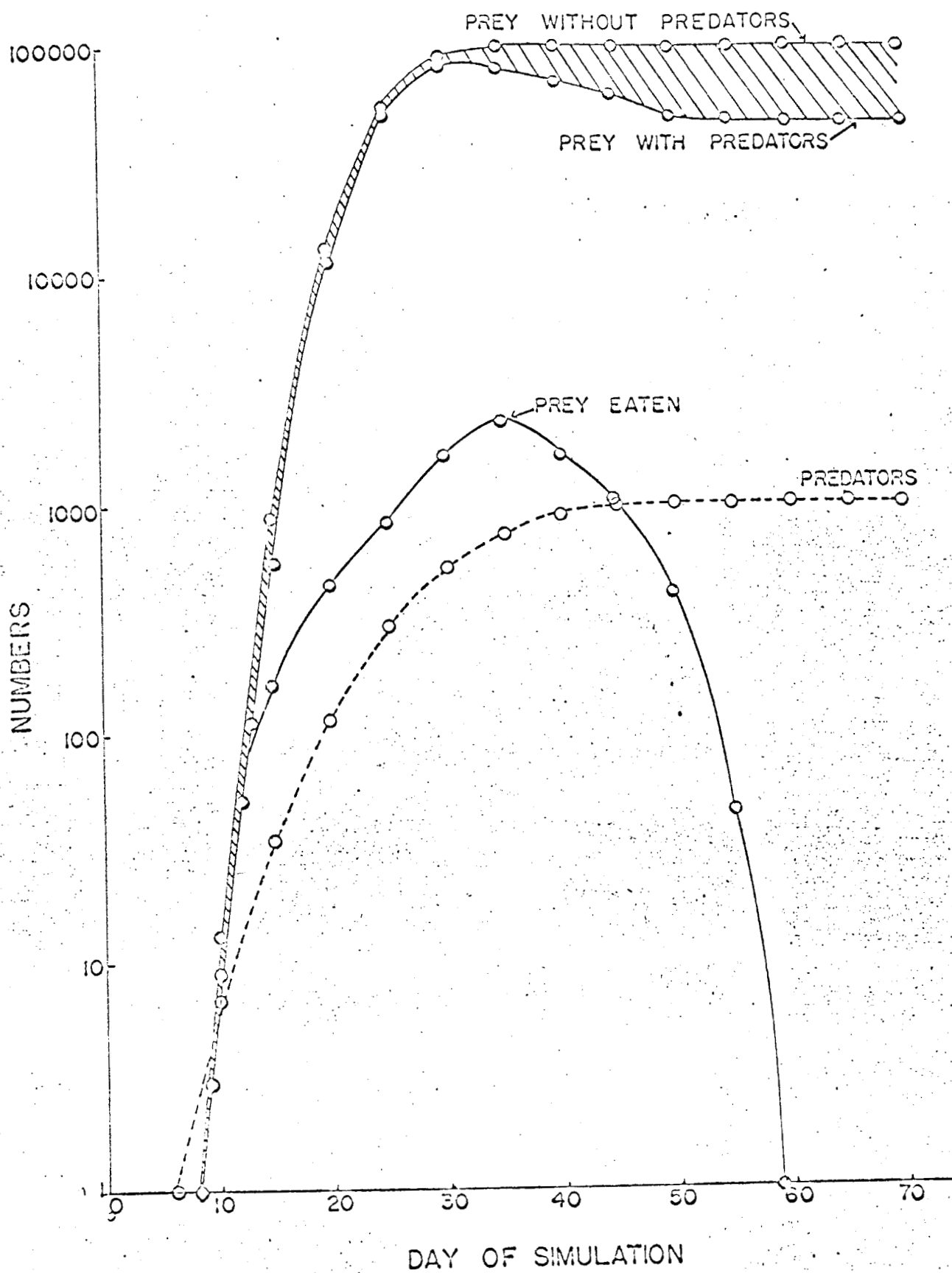


Figure 3.

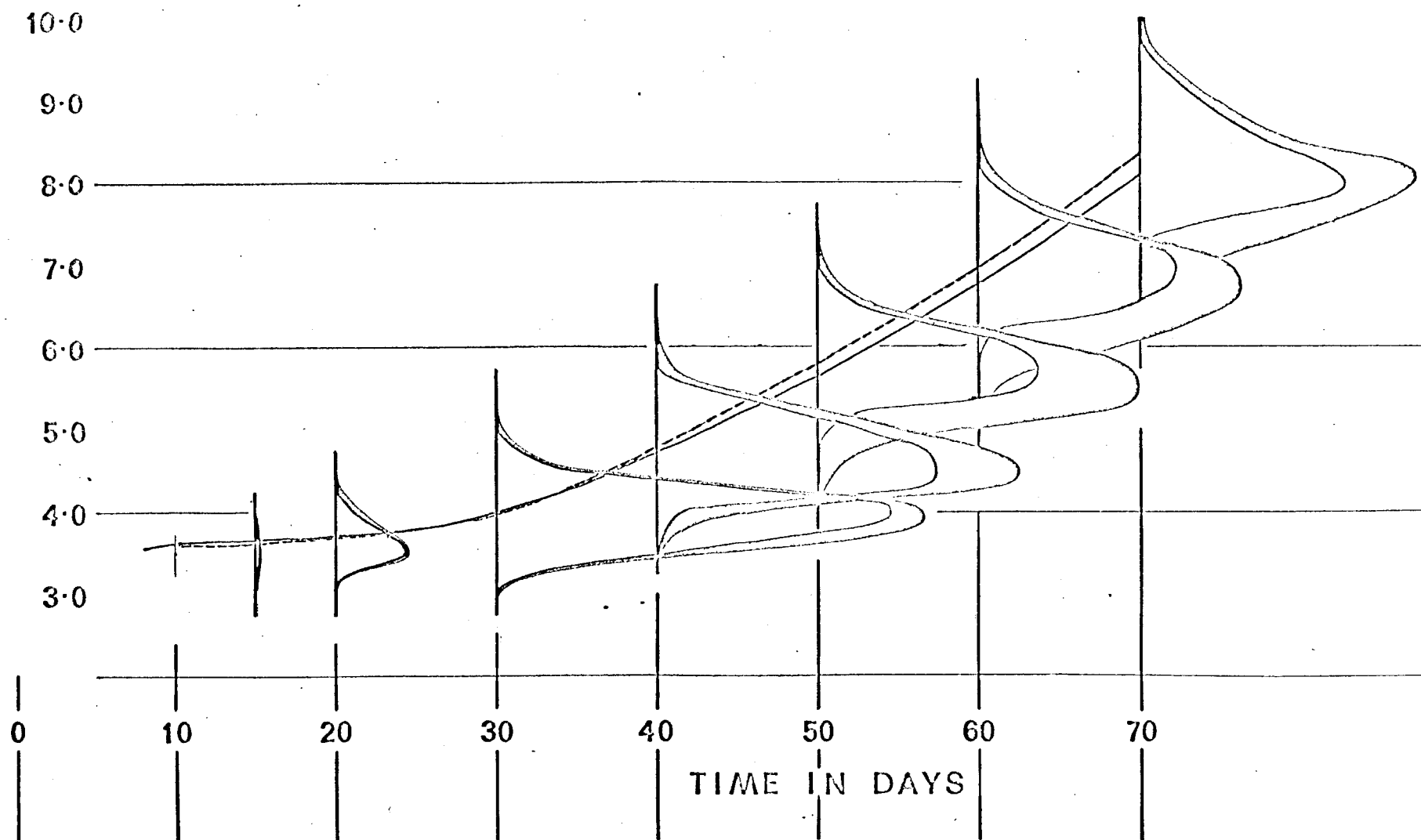


Figure 4.

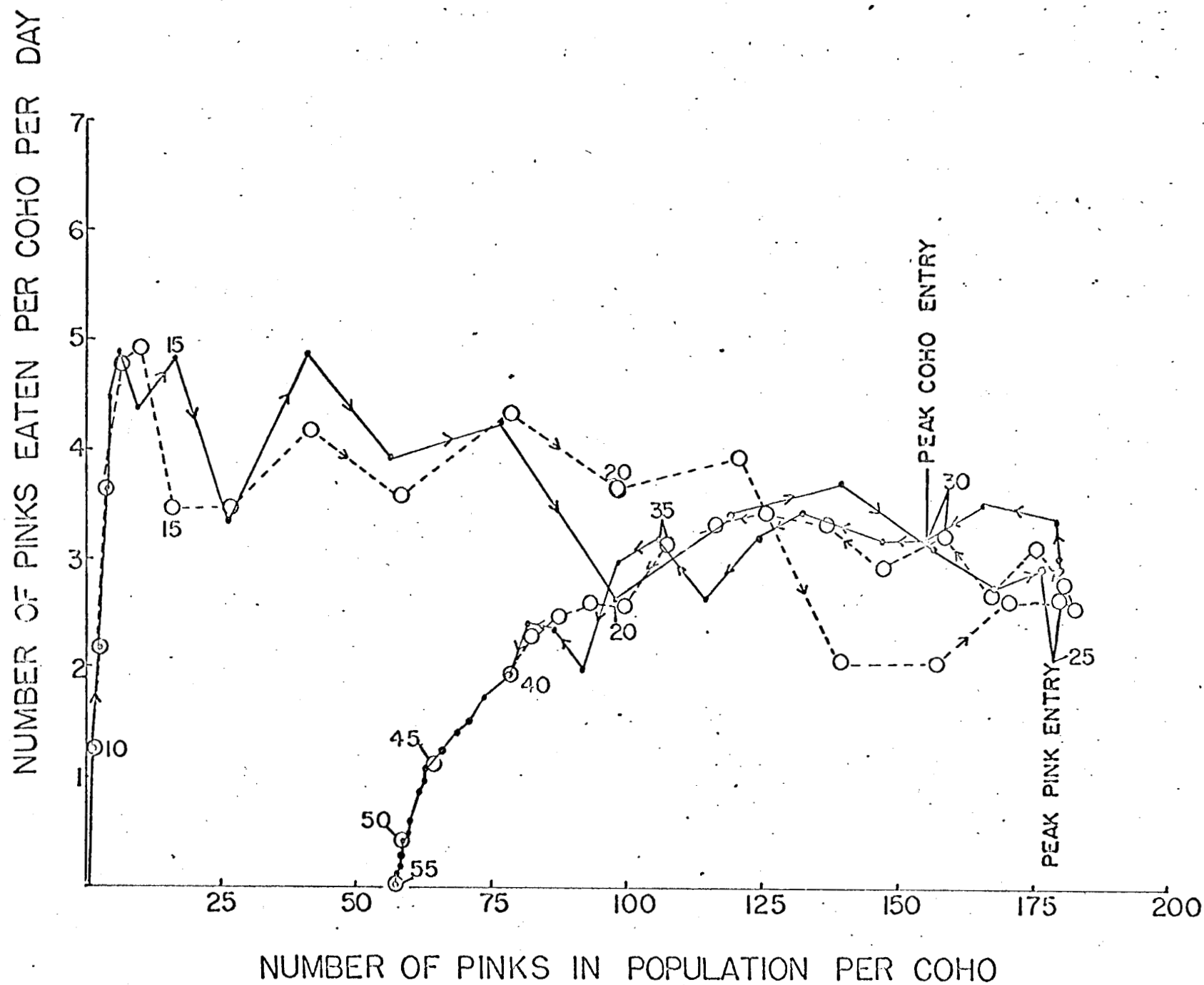


Figure 5.

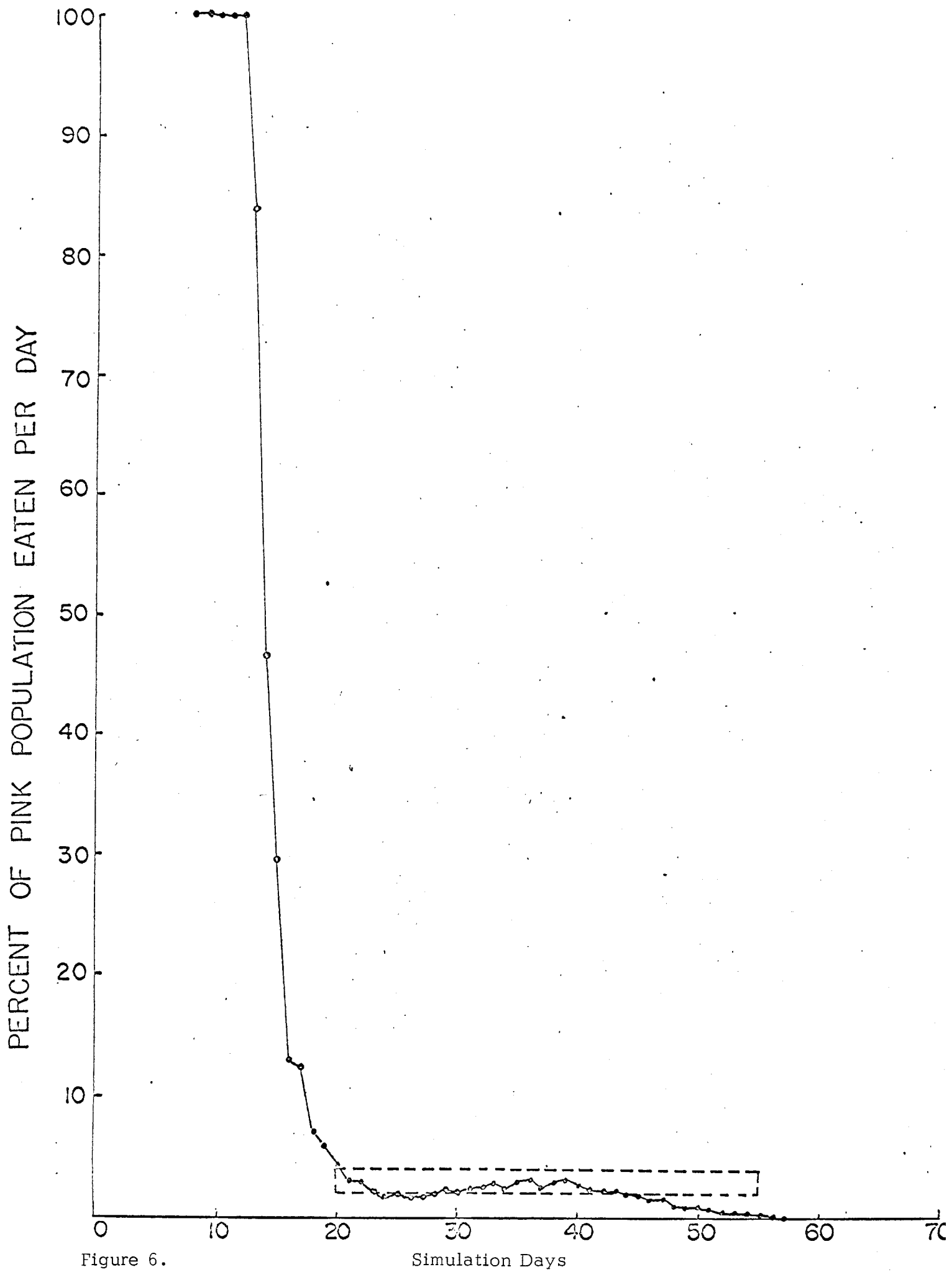


Figure 6.

Simulation Days

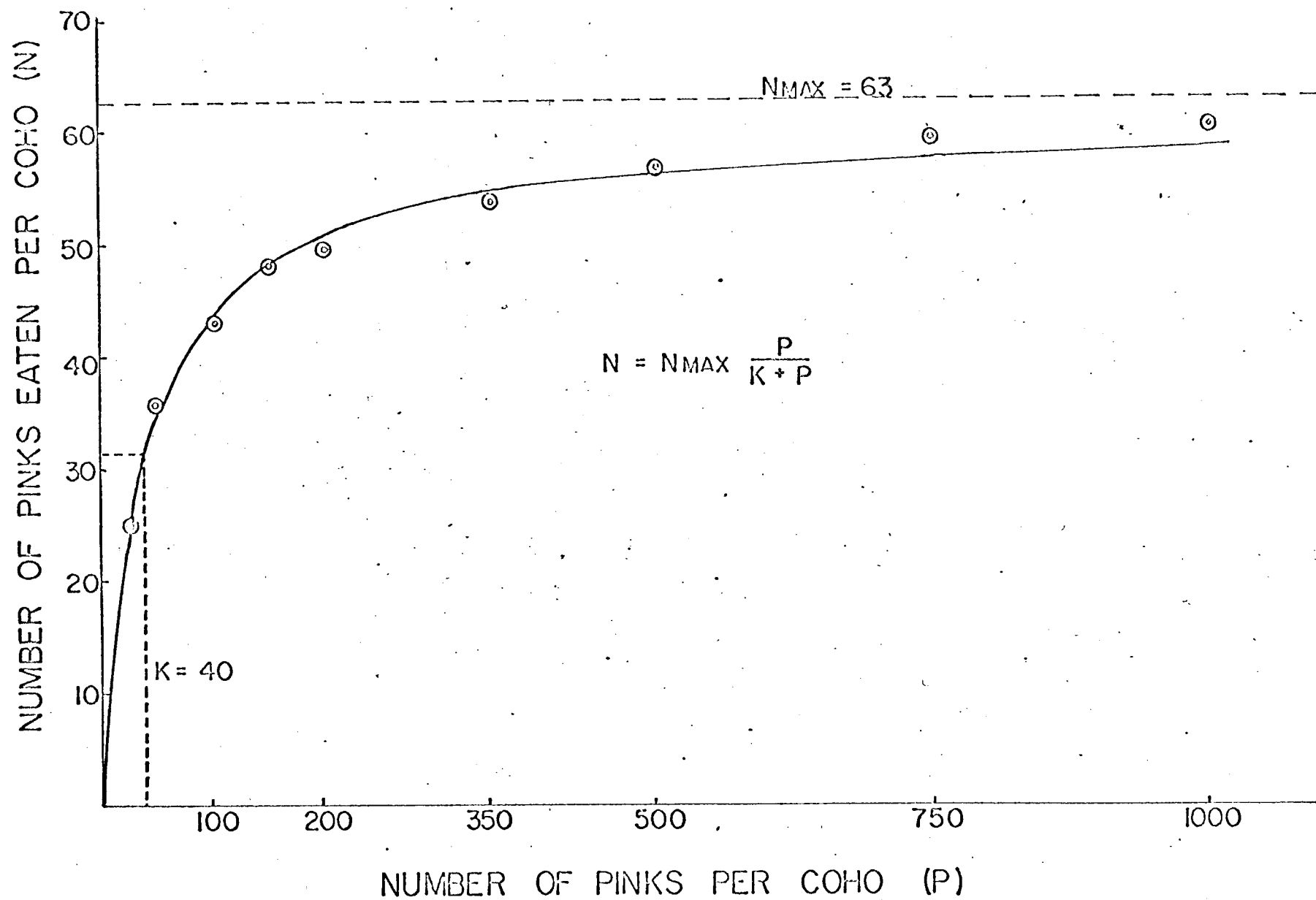


Figure 7.

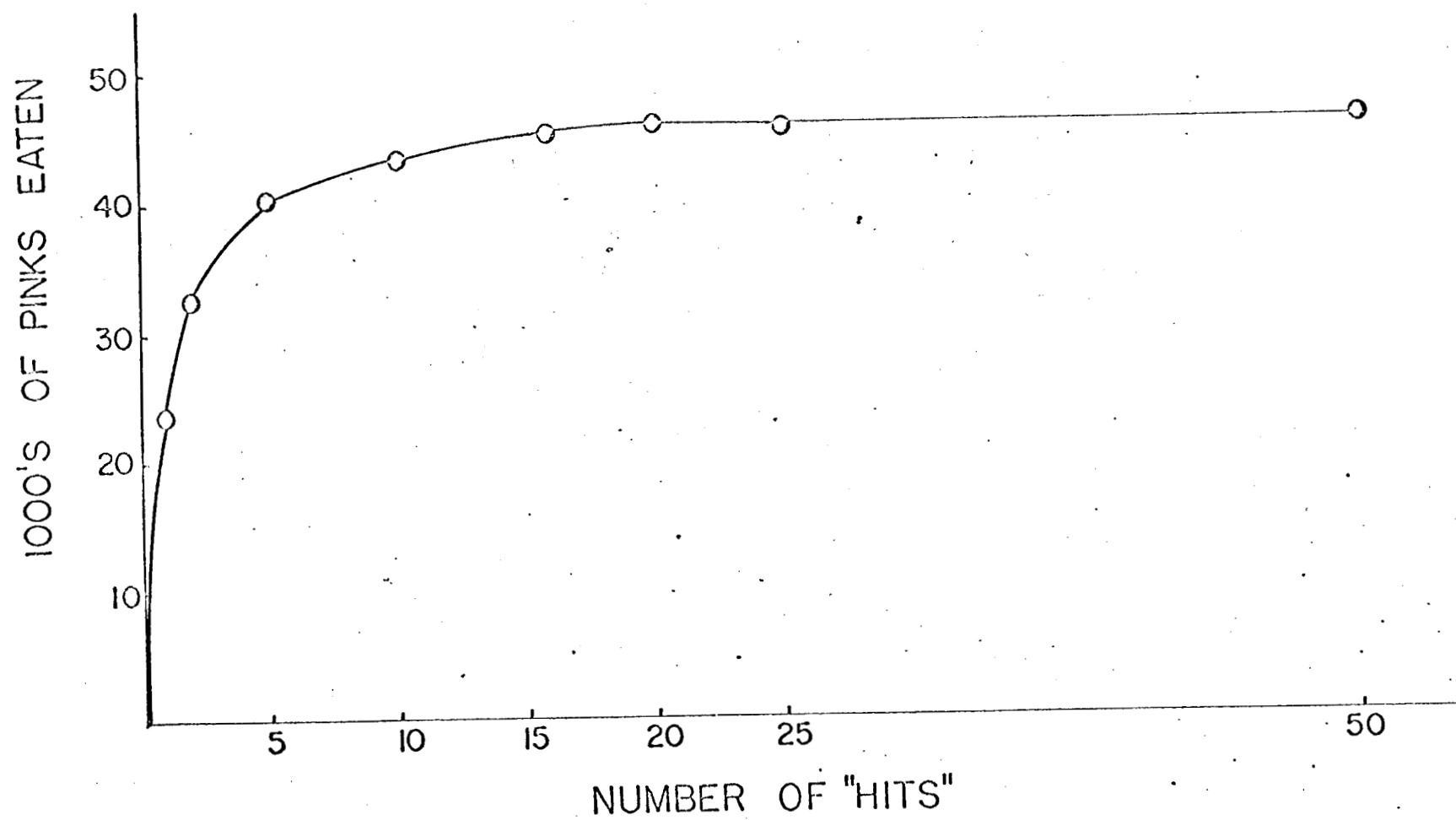


Figure 8.

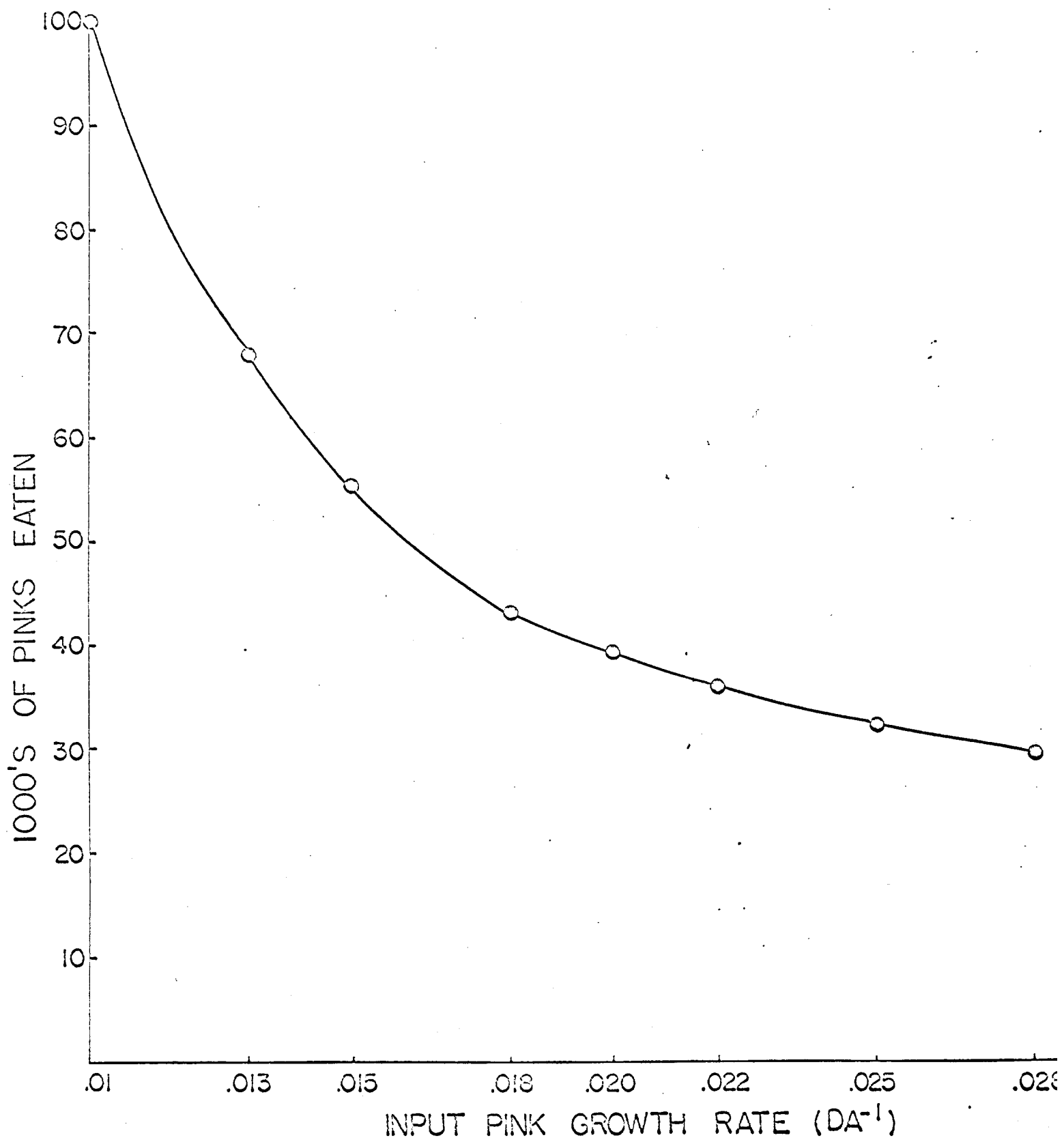


Figure 9.

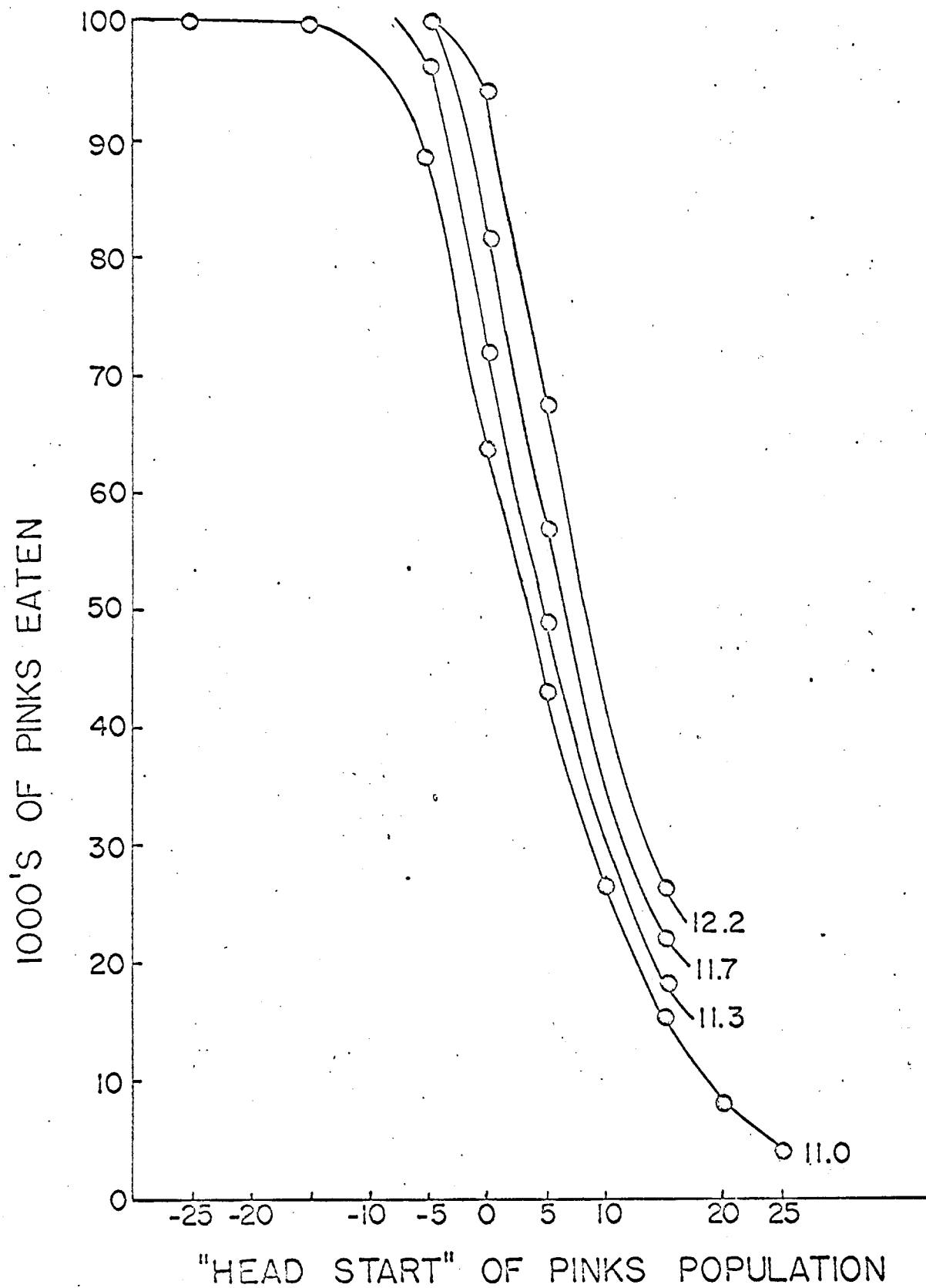


Figure 10.

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TABLE 1.

The following statistics are applied to produce a so-called "standard run". These define a run and may be changed in any way to simulate the desired situation.

Prey population - Pink salmon fry

Size at entry: mean 3.6 cm, standard deviation 0.15 cm.

(Bella Coola R., Hooknose Cr.)

Length-Weight relationship:  $W = 0.00457 L^{3.267}$

(LeBrasseur and Parker, 1964, Bella Coola)

Growth rate:  $0.018 \text{ day}^{-1}$

(LeBrasseur and Parker, 1964)

Time of entry: mean Julian day 110, standard deviation 4 days

(Hunter, 1959). Note 1.

Size of population: 100,000 fry. Note 2.

Predator population - Coho salmon fry

Size at entry: mean 11.0 cm, standard deviation 0.5 cm.

(Hooknose Cr.)

Length-Weight relationship:  $W = 0.0129 L^{2.869}$

(Hooknose Cr.)

Growth rate:  $0.007 \text{ day}^{-1}$

(Hooknose Cr.)

Time of entry: mean Julian day 115, standard deviation 8 days

(Hunter, 1959). Note 1.

Population size: 1,000 fry. Note 2.

Table 1 (continued) .

Maximum daily ration: 0.12 of body weight

(Parker, 1971)

Maximum prey size: 0.044 of body weight.

(Parker, 1971)

Maximum number of hits: 10

#### Notes

1. These mean times of entry produce a "head start" of 5 days.
2. The long term average ratio of prey to predators for Hooknose Cr. was 120:1 (Hunter, 1959).

# STUDY OF FINGERLING PINK SALMON AT KODIAK ISLAND WITH AN EVALUATION OF THE METHOD OF FORECASTING BASED ON TOWNETTING

Richard Tyler, Fisheries Research Institute

## BACKGROUND

Our study of young pink salmon at Kodiak Island was begun in 1962 with the objective of forecasting the return runs. A method of sampling in which a specially modified surface trawl is towed between two boats was tested and found to be an effective means of obtaining indices of abundance of the fingerlings offshore in the bays during July, to serve as bases for forecasting the return runs. By this time the populations have passed through an assumed period of variable marine mortality, the first two months in salt water. In 1970 the study was expanded to include the food, feeding habits, and growth of the fingerlings and associated species.

## FORECAST STUDY

### Materials and Methods

The methods and equipment used have been reported in the Proceedings of the 1966 Northeast Pink Salmon Workshop, and so will be described here only briefly.

The net is designed to be fished from the open deck of the Institute's 38-ft. purse seiner, MALKA, and held open with an inboard-powered seine skiff abreast of the MALKA and about 50 ft. to one side. It has been used with other types of vessels but with less success. Its dimensions and specifications are as follows: width, 20 ft.; depth, 10 ft.; length 56 ft.; mesh of knotless nylon in graduated sizes (stretch measure), from 3 inches at the entrance to 1-1/2 inches to 3/4 inch to 1/4 inch at the cod end; double-layered cod end. The entrance is held open vertically by two spacer bars, each with 20-lb. lead weights attached to the bottom and with 14-inch inflated neoprene floats attached to the top. The net is set and hauled manually. A standard haul lasts 10 minutes, and speed of towing is 2.4 knots (4 fps). The duration of setting and hauling is minimized by means of 25-ft. warps.

The fishing strategy is as follows: 1) Replication annually of a series of hauls calculated to encompass all parts of a given sampling bay in proportion

to surface areas. These hauls are designed to provide the basic information needed for computation of the index of abundance. 2) Additional hauls to define the limits and relative densities of any unusual concentrations of fingerling pink salmon. These hauls are intended to improve the accuracy of the index. A total of 357 standard hauls is made, together with an additional 20 to 40 hauls in areas of high fish density, over the 387 square nautical miles of the study bays. Hauling is done usually either vertically or diagonally to the shoreline so that bias due to near-shore schooling will be minimized. This bias has been shown by past catch data to be negligible after the fingerlings have left the shoreline, usually after mid-June.

The forecast indices are estimates of total fingerling abundance calculated from the catches. The estimates are weighted by area by a method in which the catches are plotted, delineated by isopleths, weighted, and summed according to the following formula:

$$\frac{(A_1 + A_2 + \dots + A_x) \bar{X}_a + (B_1 + B_2 + \dots + B_x) \bar{X}_b + (N_1 + N_2 + \dots + N_x) \bar{X}_n}{dL}$$

where A, B, ---N = the areas between isopleths 0 to 10, 10 to 50, ---n to 5n,

n = the number of isopleths needed to encompass the range of catches,

$\bar{X}_a, \bar{X}_b, \dots \bar{X}_n$  = the mean catch values within isopleths 0 to 10, 10 to 50, ---n to 5n,

d = the width of the net, and

L = the length of one haul.

The values of the isopleths increase geometrically by a factor of 5. The catch efficiency of the net is unknown, but for indexing purposes is assumed to be 100 per cent across the net opening. Because the actual catch efficiency is probably less than 100 per cent, the estimate is minimal.

#### Forecast Strategies and Their Success

During the nine years of this study, two forecast strategies have been attempted: 1) a forecast of returns to individual bays, and 2) a forecast of the total returns to the Kodiak-Afognak Island area.

The first forecast strategy was followed during the years 1963 to 1968. We assumed that the accuracy of the forecast would be greatest if it was restricted to the bays from which indices had been obtained. At first we selected for study two of the larger and more productive bays, Alitak and Uganik; later we added Uyak, Kaiugnak, and Ugak. After several years of forecasting it became apparent that the strategy was only moderately successful. Only the unusually large or the unusually small runs were reliably predicted, and significant inaccuracy in predicted returns to the individual bays resulted from the fact that substantial numbers of fish were often intercepted by the fishery off adjacent bays and were so reported in the catch statistics.

The second forecast strategy has been in effect since 1968 and has resulted in greater accuracy. The index area has been increased, and a forecast of total returns to the Kodiak-Afognak Island is derived from the indices for all bays. Assignment of catches to home streams has been much more precise since most pink salmon caught around Kodiak and Afognak Islands are destined for local streams. The bays surveyed annually drain most of the important watersheds--Alitak, Kaiugnak, Kiliuda, Kazakof, Izhut, Pernenosa, Malina, Terror, Uyak, Zachar, and Uganik (Figure 1). Pink salmon from two of the more productive systems, Karluk River and Red River (Figure 1), cannot be sampled by townetting because they enter directly into ocean waters; hence the forecasts for these systems are calculated from the escapement-return relationships during the past decade.

The success of forecasts to date was evaluated by combination of all indices by the method used at present. Indices for individual bays for the years 1963 to 1968 were included in the analysis from hindcasts of the total returns for 1964 to 1969 (Figure 2). A coefficient of correlation ( $r$ ) of 0.84 was found between forecasts and returns.

#### Experiments to Determine the Variability of Catches and Optimum Method of Trawling

In 1967 and 1968 experimental trawling designed to show the variability of trawl catches and the relative efficiency of various trawl configurations was conducted in Alitak Bay and Uganik Bay.

Three different trawl configurations were tested, in all of which paired trawls were towed between the MALKA and two seine skiffs. In the basic configuration both nets were fished at the surface at the same distance behind the boats (Figure 3). The effect of warp length was measured by lengthening of the towline on one of the nets by 100 ft. In both cases hauling was continuous and

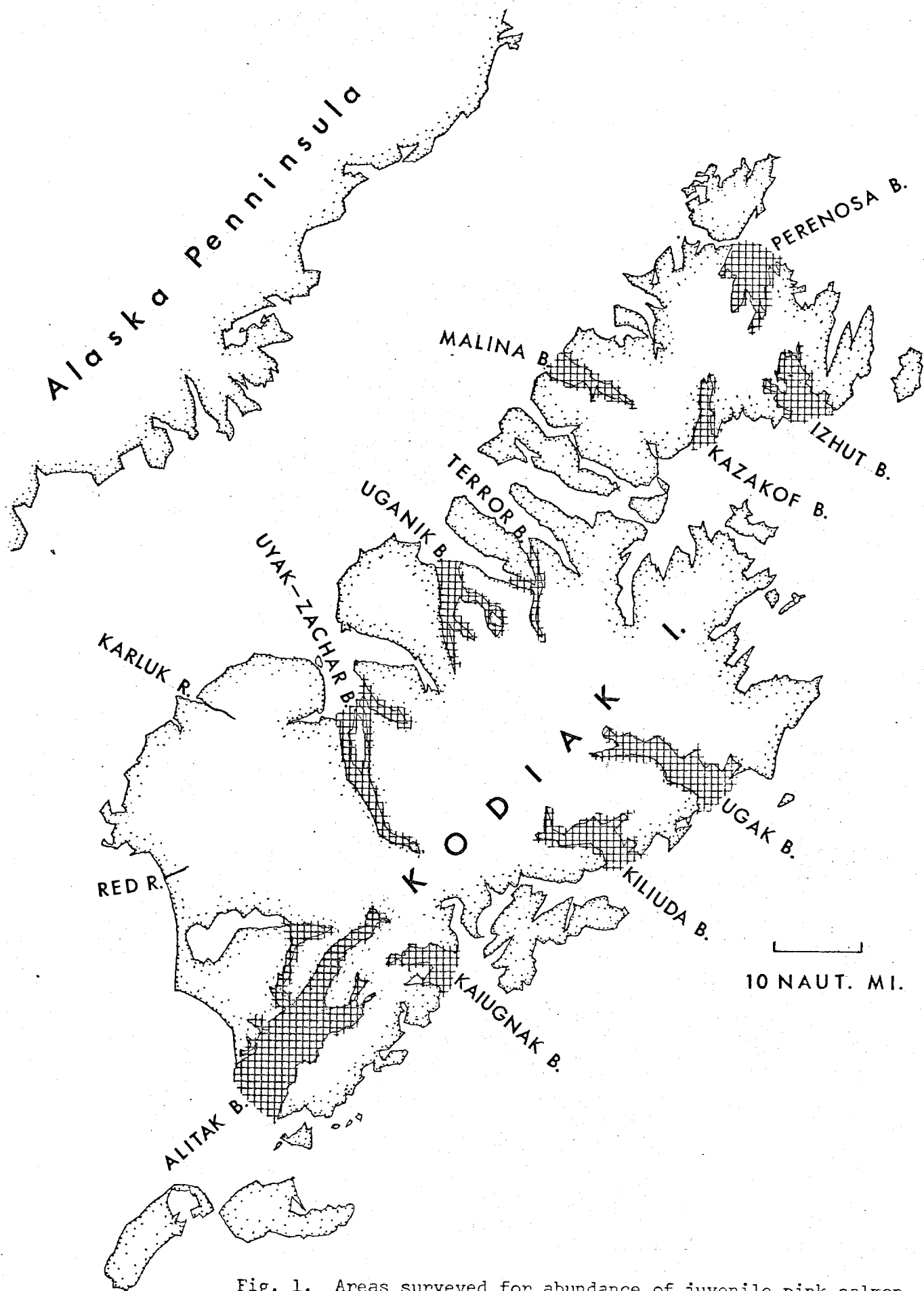


Fig. 1. Areas surveyed for abundance of juvenile pink salmon.

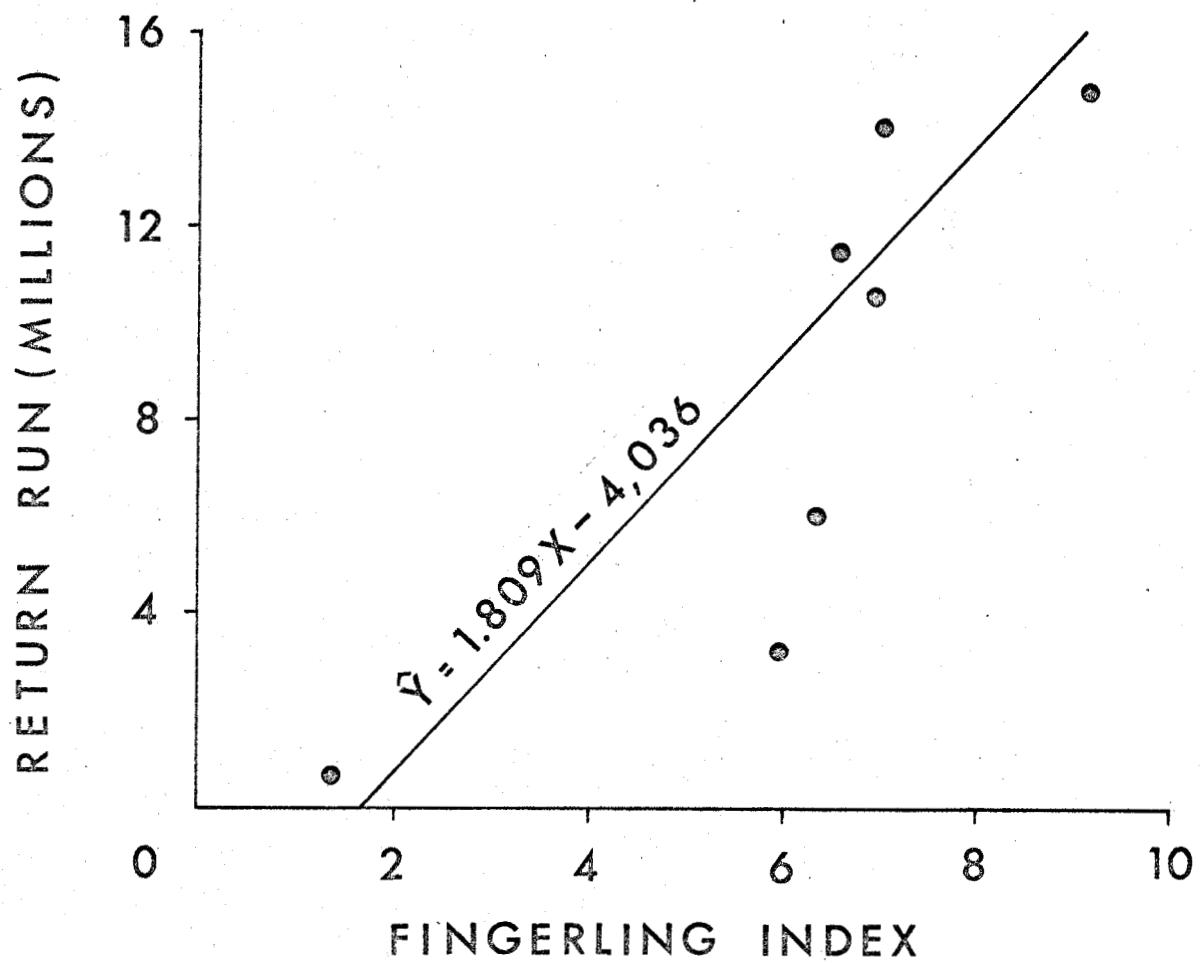


Fig. 2. Relationship between pink salmon forecasts and returns.

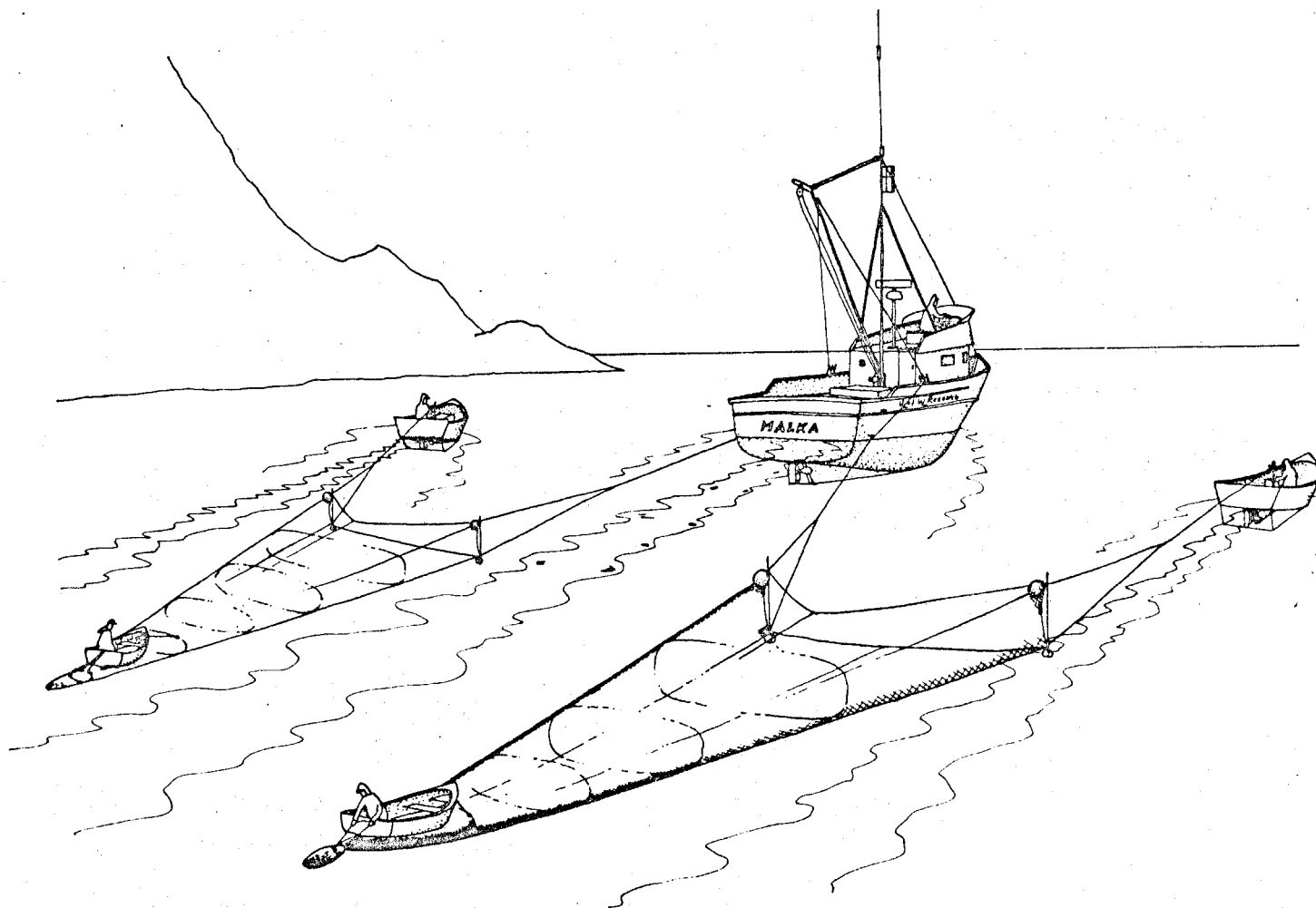


Fig. 3. Sketch showing simultaneous towing of paired trawls.

a man rode in a pram on the cod end of each net and checked the catch at 5-minute intervals. The effect of depth was examined by lengthening of towing lines on both nets and removal of the floats from one net so that it fished with the top submerged 5 ft. Since a cod-end pram could not be employed with the deep net, both nets were hauled for 10-minutes and then brought aboard the MALKA. A total of 423 paired hauls was made in areas of low, moderate, and high fingerling density. Of 292 net-comparison hauls, three series totaling 172 hauls were made at night. All other trawling, including the 30 depth-comparison hauls and 101 warp-comparison hauls, was done in daylight.

Analysis was complicated by two unforeseen factors: 1) a small difference in the construction of one net resulted in a substantial difference in catching efficiency; 2) the catch distributions did not approximate known distributions (Figure 4), thus the analysis was limited to nonparametric statistics.

Nets of identical design and materials made by the same builder were used during the comparative trawling; however, midway in the experiments one net was torn and had to be replaced by a new net. The new net was hung with more netting in the small-mesh section of the cod end and consistently caught more fish than the old net. The difference in catch was more pronounced during daylight hauls (36 per cent) than during nighttime hauls (20 per cent); thus, it is apparent that visibility has considerable effect on the efficiency of the tow net. The variability introduced into the data by the use of the new net reduced the statistical significance of observed differences.

Previous observations of the reactions of young salmon to the approach of the towing vessels had shown that in shying away from the vessels the fish tended to funnel into the path of the net; therefore, we had concluded that having the tow net positioned immediately behind the towing vessels would be the most productive location. A comparison of three series of paired catches from nets with 25-ft. and 125-ft. warps by means of the Wilcoxin Signed Rank Test indicated no significant difference, however. The funneling, if it exists, apparently has an equal effect with both short and long warps.

The catches of surface and subsurface hauls were shown to be distinctly different by a comparison of the yields from three series of 10 daytime hauls in which the nets fished at depth of 0 to 10 ft. and 5 to 15 ft. Since both nets fished the 5-10 ft. depth, the comparison was actually between the catches at 0 to 5 ft. and 10 to 15 ft. Few fish were caught in the deep hauls, averaging only 5.5 per cent of the surface net catch and exceeding the surface net catch on only one of 30 hauls. The large difference in catches suggests that nearly all fish occurred above 5 ft.

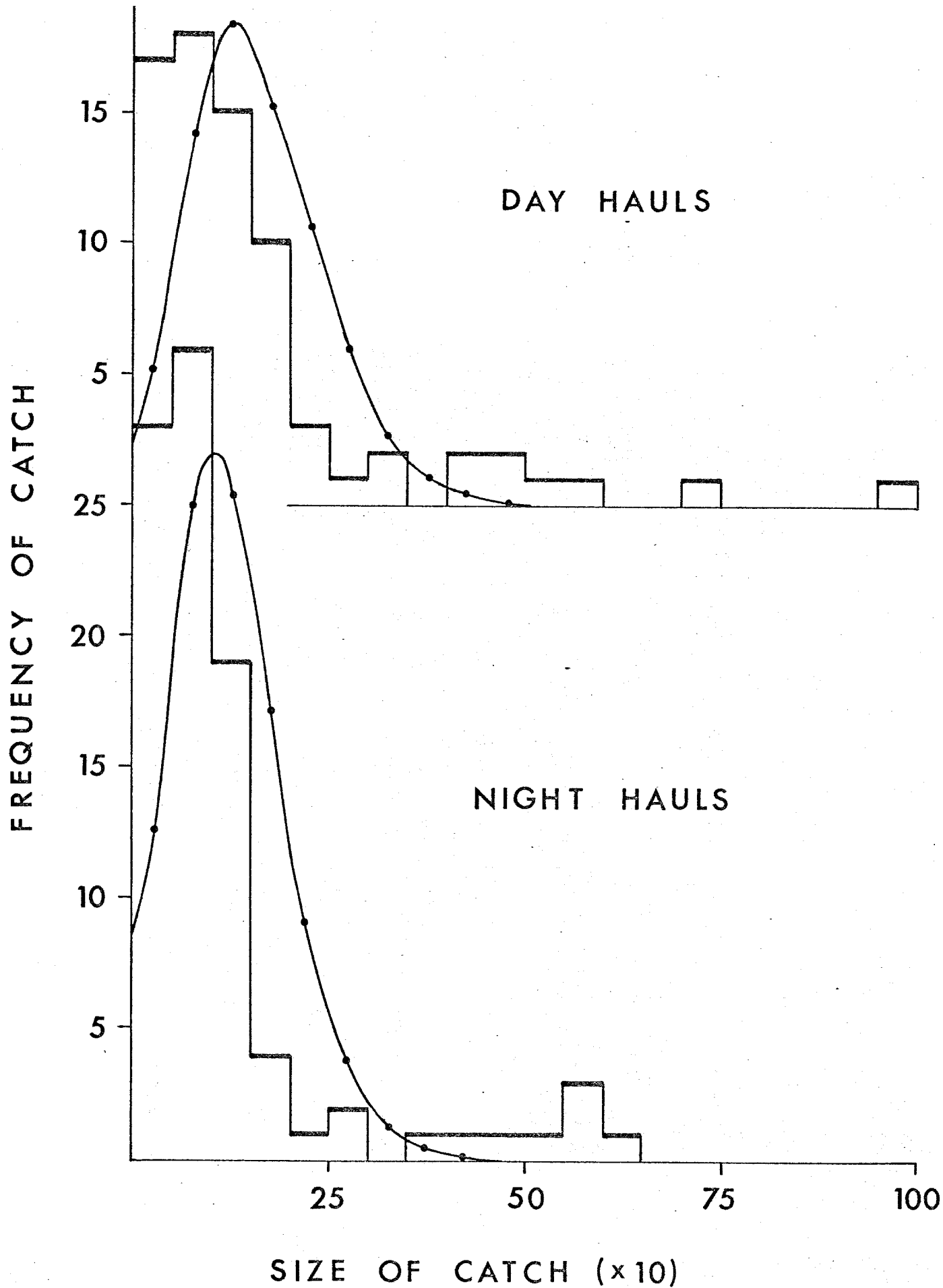


Fig. 4. Comparison between catch distributions of day and night hauls. The distributions are fitted with Poisson curves.

The effect on catch rate of the diurnal behavior of young pink salmon was studied by comparison of the yields from three replicate series of hauls made during midday at a location with those of an identical series made 12 hours later at the same location. The Wilcoxin-Mann-Whitney Test of smaller rank sum was used. The results indicated little or no difference in the total numbers of salmon caught but a decided difference in the distributions of the catches. Variability in the catches typically was high during daylight and lower at night (Figure 4). This difference is attributed to the strong tendency of young pink salmon to school whenever they can orient visually, thus they are most randomly distributed during the darkest hours at night, 2300 to 0200 hours during July. It is apparent that survey trawling should be conducted at night, as has been the practice in most of the Kodiak forecasting work.

#### FOOD AND GROWTH STUDY

A study was begun in 1970 in conjunction with the index surveys for the purpose of providing basic information on the food and feeding habits of fingerling pink salmon in relation to the availability of zooplankton and of comparing the food habits of fingerling pink salmon with those of juvenile whitespotted greenling (Hexagrammos stellini) and fingerling chum salmon.

Extensive sampling of zooplankton was conducted simultaneously with the sampling of fingerlings by horizontal hauls with a 30 cm net at the surface and at depths. Temperature profiles were taken with an induction salinometer. Most of the effort was devoted to Alitak and Kiliuda Bays; Alitak was sampled at the beginning and at the end of the season, and Kiliuda Bay four times during the season. In Alitak Bay a series of replicate samples was taken in an area of low fingerling abundance and in an adjacent area of high fingerling abundance.

To date, the major organisms found in the plankton samples have been copepods, copepodids, decapod zoea, and nauplius larvae. A preliminary analysis of the stomach contents of fingerling pink salmon showed that their diet consisted chiefly of young and lance, winged insects, copepodids, harpacticoids, and zoea, in that order. A quantitative, volumetric sampling of the stomach contents of juvenile greenling indicated that in most areas decapod zoea were by far the predominant food organisms, followed by young sand lance and copepodids.

The diet of greenling is being studied because of the pronounced tendency of the juveniles to school with juvenile pink salmon and thus the possibility of detriment to the latter from competition for food or space. That the

affinity is an attempt by the greenling to obtain protection from predators within the school seems likely in view of the fact that they have the same coloration and body form as the fingerling pink salmon during the latter's short period of estuarine residence. After the pink salmon have left the bays, the greenling metamorphose into adult coloration and body form. As indicated above, little overlap has been found in the food preferences of the two species.

PANEL III.

ARTIFICIAL PROPAGATION

PANEL LEADER: R. A. Bams  
FRBC, Canada

R. Sato, Co-leader  
Tohoku University, Japan

## EVALUATION OF SOCKEYE SPAWNING CHANNELS

Roger Kearns, Canada Fisheries Service

No abstract submitted by the speaker.

# EVALUATION OF BAMS-BOX HATCHERY ON TSOLUM RIVER PINK SALMON

R. A. Bams, Fisheries Research Board of Canada

On the basis of newly discovered and appraised biological requirements of larval Oncorhynchus a new hatchery method was designed utilizing filtered water and gravel substrate. Four tests of the method have been carried out to date by the Pacific Biological Station. All tests showed significantly increased survival rates to the fry stage and no change in growth and developmental rates when compared with wild stock. The only difference observed was premature emergency, by from 1 to 2 weeks, of the hatchery fry.

One test on Tsolum River pink salmon was carried through to the adult stage. Some 75,000 fry of each treatment (wild and hatchery) were marked by finclipping and released. Upon return 1,166 marked adults were recovered from the fishery and the river. The gain ratios (survival in hatchery over wild) was, at the fry stage 6.04, for the actual adult recoveries 6.00, and for the estimated total returns prior to fishing mortality 6.27 for the marked fish and 6.16 for the unmarked fish. No significant differences were measured between the adults of both treatments in fish size, timing of the runs and of egg deposition, and fecundity. These two major findings, the retention to the adult stage of the gain originally obtained in the hatchery, without detriment to the fish in several important characteristics, lead to the conclusion that this test was completely successful in significantly increasing the numbers of normal appearing adults for a given number of available eggs.

## Fry Data HQ (1968)

	Sample	Creek	Hatch.	$\Delta$
At emergence				
Length, mm	p.s.m.	32.66	31.93	-0.73
Length, mm	w.m.	33.02	32.32	-0.70
$k_p$ -value	p.s.m.	1.891	1.925	0.034
	w.m.	1.898	1.921	0.023
Weight, mg	w.m.	247.3	240.3	-7.0
After conversion				
Length	p.s.m.	32.66	32.78	+0.12
Length	w.m.	33.02	32.90	-0.12

Adult Data HQ (1968)

	Creek	Hatch.	Total
Released fry	75,000	77,000	152,000
Adults			
Observed	584	582	1,166
Expected	575.5	590.5	1,166
Difference	+8.5	-8.5	17
Difference %	+0.75%	-0.75%	1.5%
Total difference %	$\chi^2$	p	

1.5	.25	.62
7.2	3.86	.05
9.0	6.67	.01
10.0	8.57	<.005 **
11.1	10.85	.001

Gain ratio

$(S_h/S_c)$ at emergence	6.04
at return	5.97
at 10% $\Delta$	5.44 **

Estimated returns

Fry to adult

Source	Location	Marked		Unmarked
HATCHERY	Catch	740		5,948
	Escapement	212		2,033
	Total	952		7,981
from fry	77,000	S = 1.24% Z = 4.39	120,000	S = 6.65% Z = 2.71
CREEK	Catch	620		2,430
	Escapement	274		830
	Total	894		3,260
from fry	75,000	S = 1.19% Z = 4.43	50,000	S = 6.52% Z = 2.73

Egg to adult

Unmarked fish	Hatchery	Creek
	S = 4.49%	S = 0.73%
	Z = 3.10	Z = 4.92

Gain ratio      6.16

at emergence   6.04

## EVALUATION OF CHUM SPAWNING CHANNELS

Fred Fraser, CFS

The following tables are subject to revision and in the very near future we will be publishing a complete series of reports on the Big Qualicum Project. I anticipate publication the spring of 1973. However, for the purpose of the informal discussion today, the data is useful.

(Chairman's comments): Mr. Fraser continued with a very detailed informal presentation of the project with the audience participating as the presentation developed.

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### Spawning Channel Parameters

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Length	3400 feet
Width (1967)	40 feet
Width (1971)	50 feet
Depth of water	.75 to 1.1 feet
Flow volume	80 to 104 c.f.s.
Flow velocities	2.0 feet/sec. (1.5-3.5)
Sections	19
Pools	18
- length	10 feet
- width	40 feet
- depth	3 to 5 feet
Spawning area	14,300 to 16,981 sq. yd.
Cost	\$199,121
Cost/yd <sup>2</sup>	\$13.92 (cost of property not included) (flow control not included)
No. of adults (opt.)	17,000
No. of females (opt.)	10,000
Sex ratio	58.8% females
Sq. yds./females (opt.)	1.7
Fecundity (mean)	3,185 eggs
Eggs/yd <sup>2</sup> (mean)	1,514
Fry/yd <sup>2</sup> (mean)	1,095
No. of eggs incubated (opt.)	30,544,154
No. of fry produced (opt.)	22,993,636
No. of adults returning	197,745
Production returns	11.6 : 1.0

# Spawning Channel #2 Migration Totals

Brood year	Spawning escapement	♀ Sex ratio	Number females	Mean fecundity	Potential deposition (000,000)	% Egg retent.	Actual deposition (000,000)	Fry migration (000,000)	Percent survival
1967	8,266	55.45	4,583	3,210	14.7	1.4	14.5	11.653	80.36
1968	14,801	43.63	6,458	3,334	21.5	4.3	20.6	17.652	85.68
1969	16,631	52.48	8,728	3,188	27.8	2.7	27.1	19.222	70.92
1970	20,286	56.27	11,415	3,086	35.2	9.0	32.0	20.534	64.16
1971	17,037	54.22	9,237	3,108	28.7	3.0	27.8	20.928*	75.28*

\* Estimate

# Female Spawners and Fry Produced per Yard <sup>2</sup>

Brood year	Area yard <sup>2</sup>	Number of females	Yard <sup>2</sup> / female	Eggs/ yard <sup>2</sup>	Number of fry	Fry/ yard <sup>2</sup>
1967	14,300	4,583	3.1202	1,014	11.653	815
1968	15,191	6,458	2.3522	1,356	17.652	1,162
1969	16,080	8,728	1.8423	1,685	19.222	1,195
1970	16,981	11,415	1.4876	1,884	20.534	1,209

Yearly Spawning Distribution

Chan. sect.	1968		1969		1970		1971	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1	1,462	9.88	958	5.76	925	4.56	724	4.25
2	1,508	10.19	690	4.15	564	2.78	1,097	6.44
3	1,267	8.56	627	3.77	607	2.99	1,036	6.08
4	1,086	7.34	614	3.69	813	4.01	915	5.37
5	1,017	6.87	627	3.77	1,885	9.29	971	5.70
6	937	6.33	2,360	14.19	1,087	5.36	869	5.10
7	897	6.06	1,821	10.95	777	3.83	816	4.79
8	824	5.57	1,478	8.89	876	4.32	906	5.32
9	577	3.90	1,054	6.34	1,682	8.29	1,293	7.59
10	687	4.64	986	5.93	1,416	6.98	1,211	7.11
11	549	3.71	845	5.08	1,284	6.33	1,140	6.69
12	463	3.13	679	4.08	1,274	6.28	940	5.52
13	568	3.84	875	5.26	1,710	8.43	1,019	5.98
14	554	3.74	694	4.17	1,189	5.86	831	4.88
15	472	3.19	409	2.46	901	4.44	685	4.02
16	477	3.22	689	4.14	937	4.62	642	3.77
17	506	3.42	509	3.06	854	4.21	739	4.34
18	505	3.41	120	0.72	600	2.96	562	3.30
19	446	3.01	599	3.60	907	4.47	637	3.74
Total	14,801		16,631		20,286		17,037	

Mean Length and Weight with Variance from Overall Mean

Spawning Channel #2

Brood year	Yearly mean length	Variance from overall mean	Yearly mean weight	Variance from overall mean	Condition coefficient
1967	39.2357	0.4453	0.354194	0.002239	0.5864
1968	39.0011	0.2107	0.359009	0.007054	0.6051
1969	39.0739	0.2835	0.355591	0.003636	0.5960
1970	37.8507	-0.9397	0.339024	-0.012931	0.6251
Overall	38.7904	-	0.351955	-	0.6029

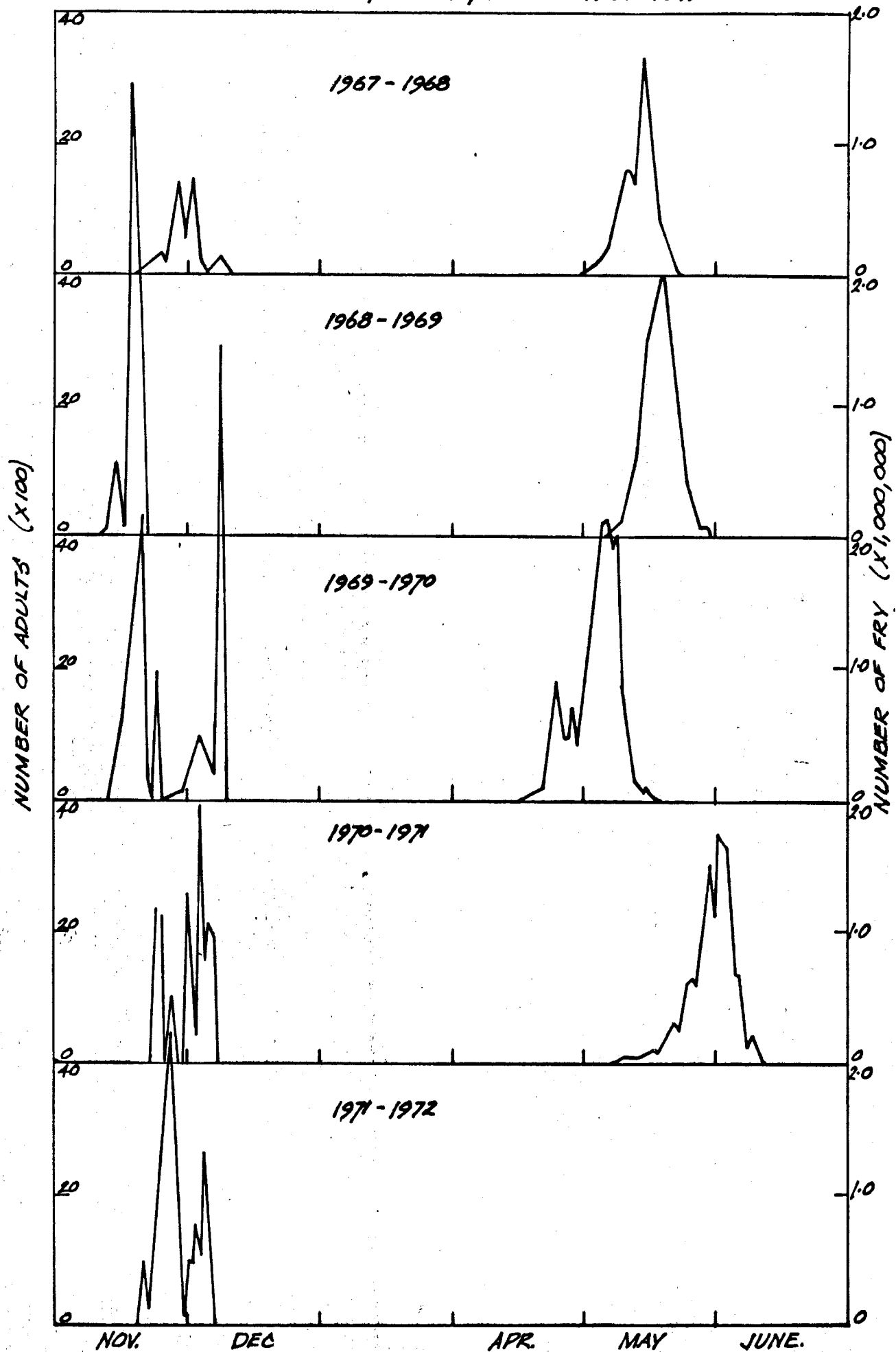
Main River

1967	39.0440	0.0266	0.36020	-0.001360	0.6051
1968	38.6977	-0.3197	0.355312	-0.006248	0.6131
1969	39.3737	0.3563	0.383914	0.022354	0.6289
1970	38.8806	-0.1368	0.353165	-0.008395	0.6008
Overall	39.0174	-	0.361560	-	0.6087

Fry marked

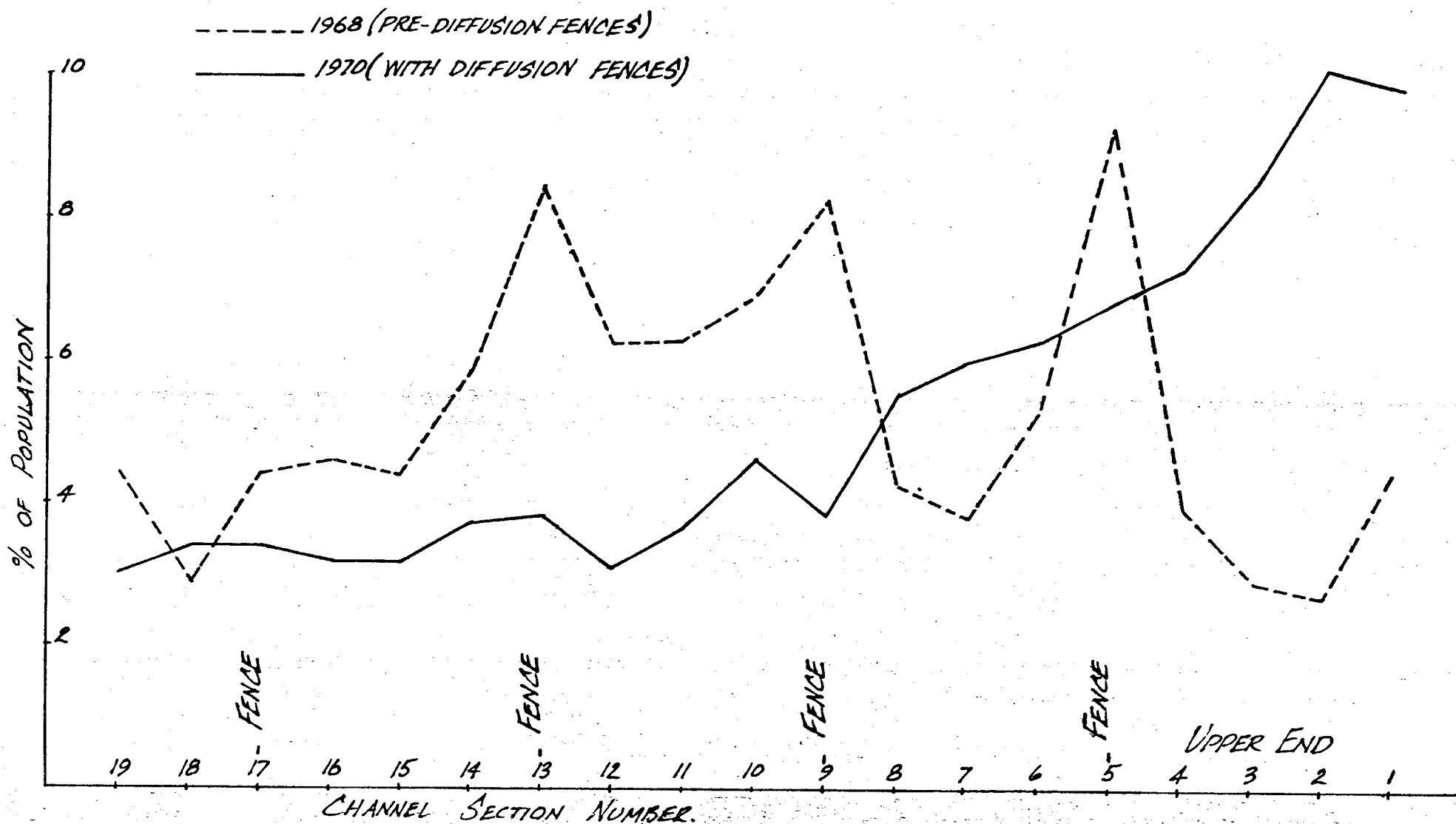
Brood year	Number produced (000,000)	Number marked	Number released	Mark type	Percent of population
1967	11.653	393,761	392,580	AD/LV	3.37
1968	17.652	448,533	446,739	AD/RV	2.53
1969	19.222	691,192	685,662	AD/RV	3.57
1970	20.534	677,217	673,831	AD/RV	3.28

**BIG QUALICUM RIVER, CHUM SALMON, SPAWNING CHANNEL 2  
TIMING OF MIGRATIONS 1967-1972**

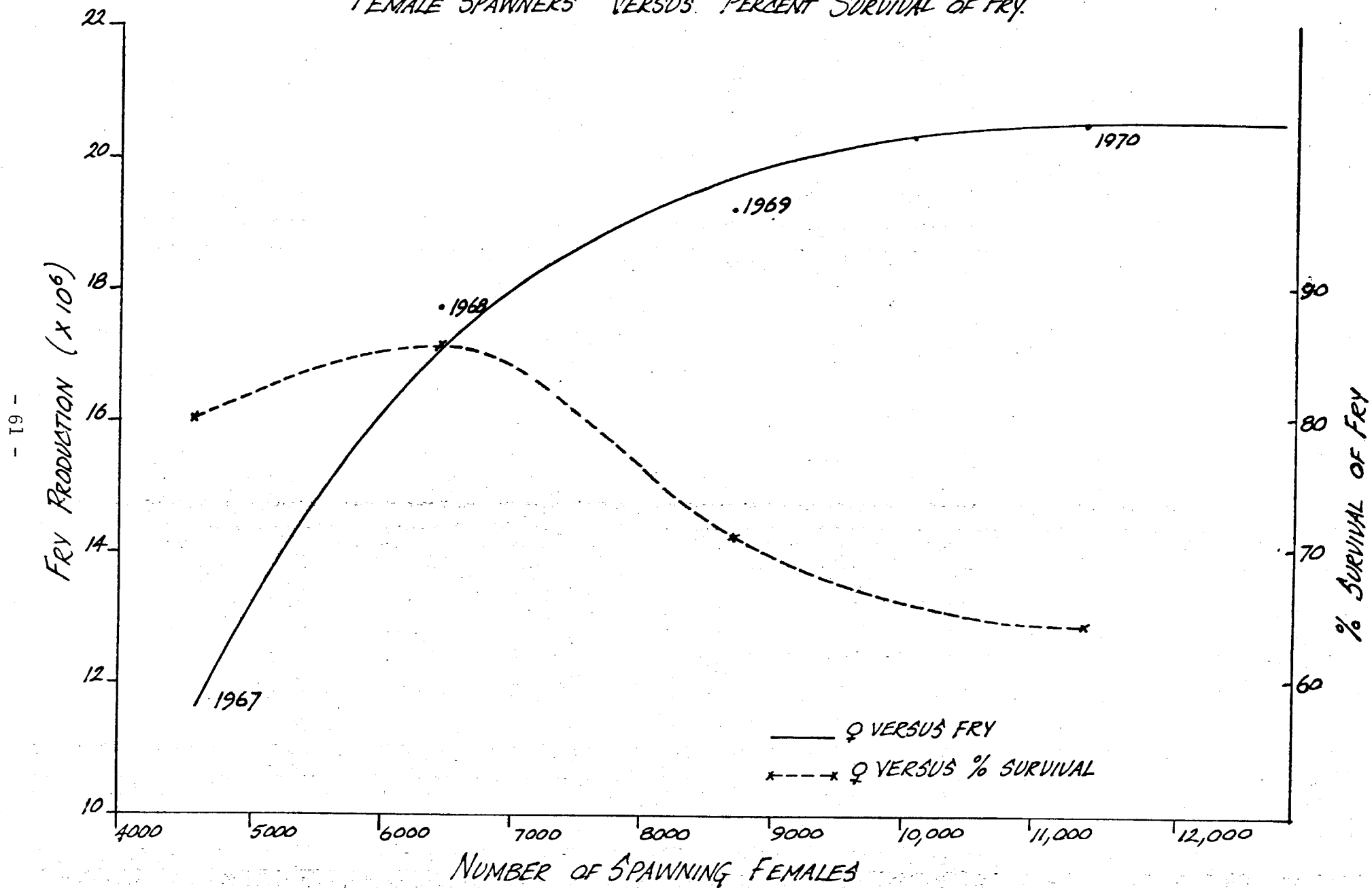


BIG QUALICUM RIVER-CHUM SALMON-SPAWNING CHANNEL #2  
(DISTRIBUTION OF SPAWNING POPULATION BY % PER SECTION)

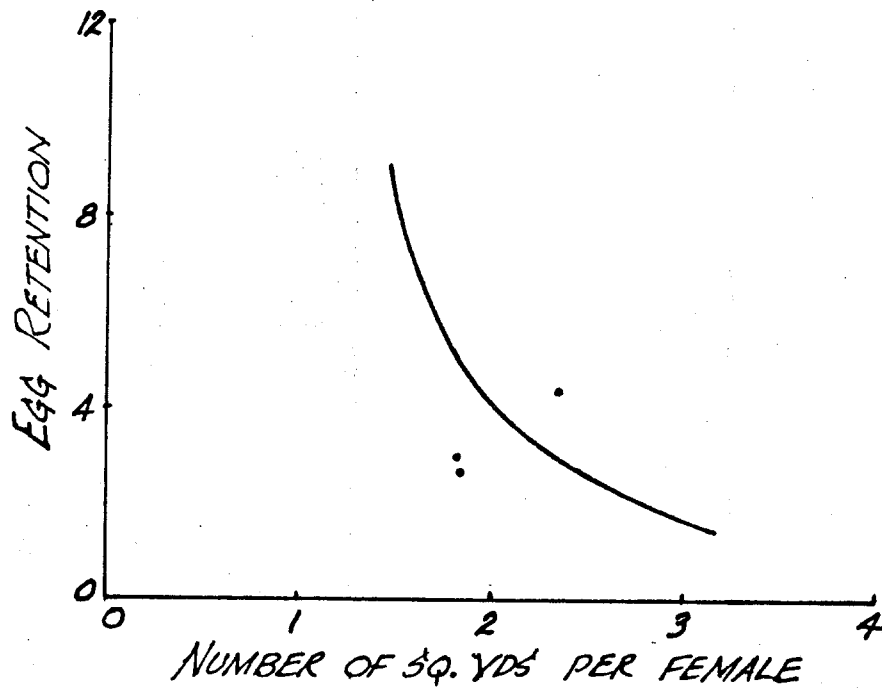
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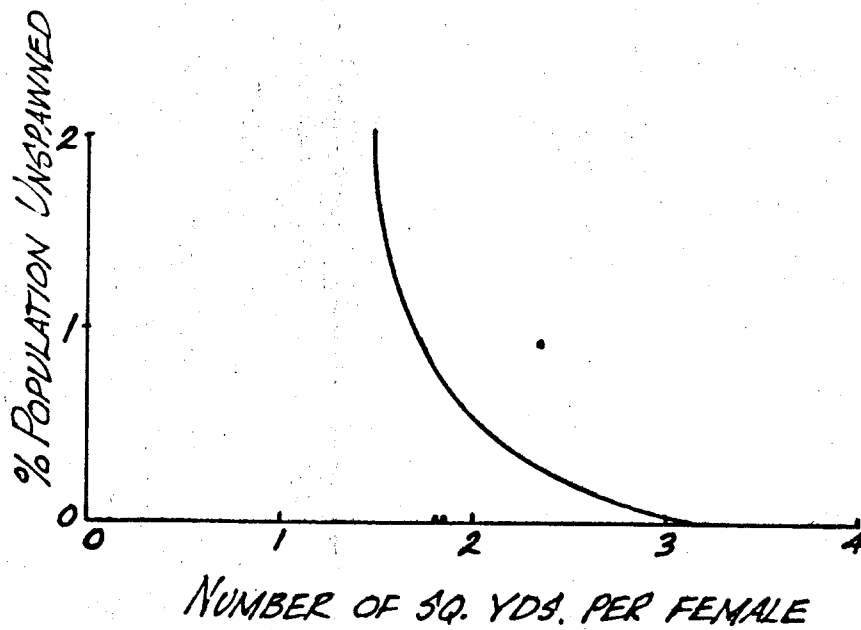
FEMALE SPAWNERS VERSUS FRY PRODUCTION  
 FEMALE SPAWNERS VERSUS PERCENT SURVIVAL OF FRY.



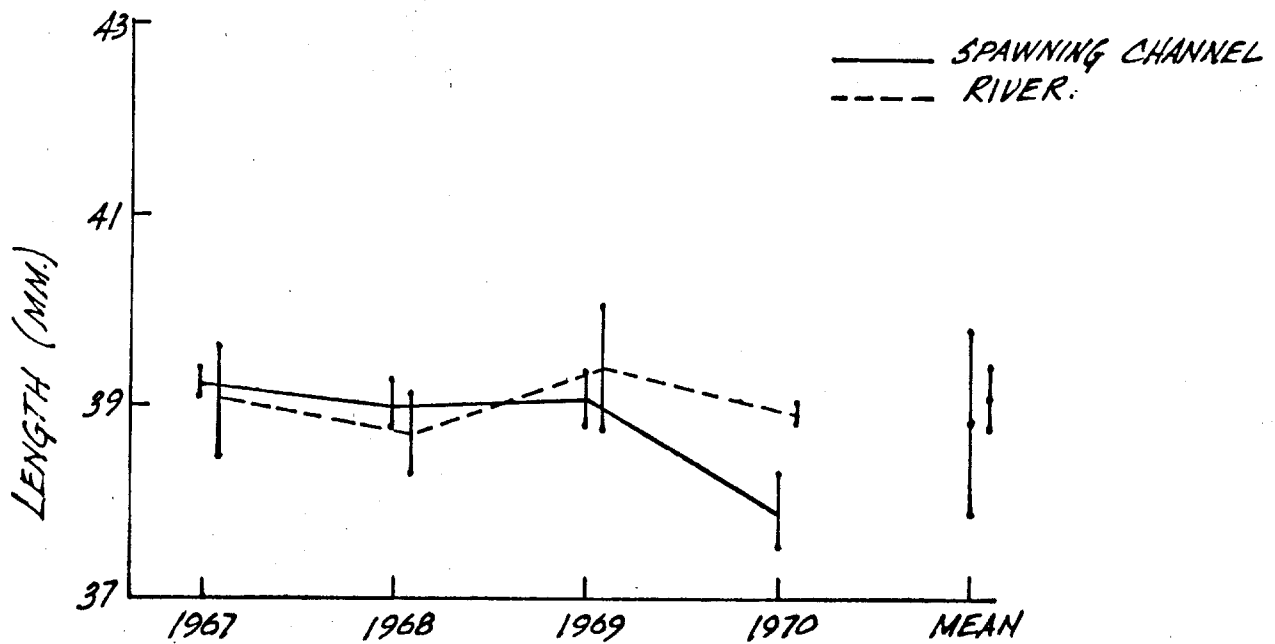
EGG RETENTION VERSUS AREA PER FEMALE



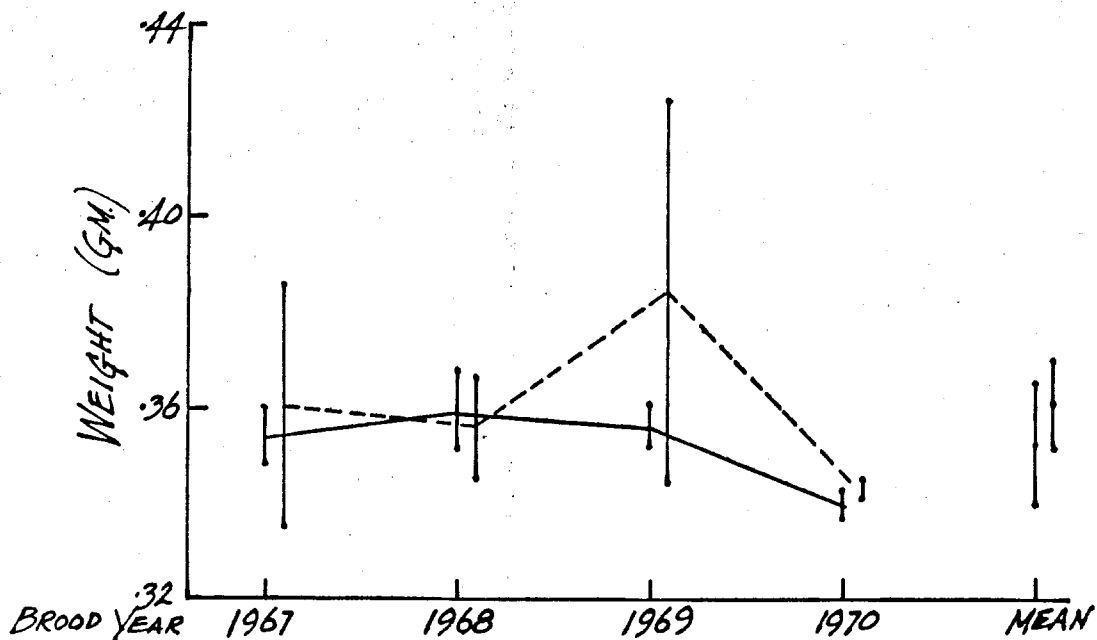
UNSPAWNED FEMALES VERSUS AREA PER FEMALE



*BIG QUALICUM RIVER - CHUM SALMON - SPAWNING CHANNEL #2*  
*YEARLY MEAN LENGTHS*  
*95% CONFIDENCE LIMITS*



*YEARLY MEAN WEIGHT*  
*95% CONFIDENCE LIMITS*



### Egg Retention

Brood year	Sq. yd./ female	% unspawned	Number unspawned	% egg retention
1967	3.12	0.00	0	1.4
1968	2.35	0.92	59	4.3
1969	1.84	0.00	0	2.7
1970	1.48	2.00	228	9.0
1971	1.84	0.50	46	3.0

### Marine Survivals (Main River)

Brood year	% fry to adult
1963	0.26
1964	0.94
1965	1.36
1966	1.44
1967	0.31 +
Mean	0.86

+ incomplete

### Predicted Returns

Brood year	Number of adults	Number of fry (000,000)	Estimated returns (total 0.86%)					Total returns
			1970	1971	1972	1973	1974	
1967	8,266	11.653	1,374+	30,857+	7,745			52,293
1968	14,801	17.652			23,788	2,095		31,053 <sup>2/</sup>
1969	16,631	19.222		5,170	59,181	103,979	2,149	165,309
1970	20,286	20.534				63,220	111,076	176,592
1971	17,037	20.928*					64,433	179,981
Total			1,374	36,027	90,714	169,294	177,658	

\* Estimated fry production.

+ Actual returns

<sup>2/</sup> Count of 4,930 in 1971 is 16% of population...total is 30,813.

HISTORICAL REVIEW OF EVALUATION OF PINK SALMON  
SPAWNING CHANNELS

Alan B. Chapman, International Pacific Salmon Fisheries Commission

No abstract submitted by the author.

## EVALUATION OF CHUM (AND PINK) CHANNELS

Ray Johnson, Washington Department of Fisheries

The Washington Department of Fisheries has one small formal eyed-egg channel, on the Satsop River, for propagation of chum salmon. Three large Columbia River channels are devoted to chinook usage. The Satsop Channel was built in 1966 as an experimental or pilot model with capacity for 2,000,000 eggs. Best success has been obtained using eyed eggs, with survival rates of 75% to 90% through downstream migration. Adult returns from releases have not been measured.

One new egg channel will be constructed in 1972 adjacent to the Skagit Hatchery on the Cascade River. Potential capacity is 32 million pink or 27 million chum eggs, with some rearing within the channel. Construction will also start this year on the spawning channel on the Wallace River, with a capacity of 8,000 adult pink salmon.

Hatchery pink salmon production continues at a minor level at the saltwater station at Hoodsport. Chum salmon have been included in the hatchery program in recent years, and during 1971 was expanded to include both salt and fresh water rearing. Results of the hatchery operations have been generally favorable, from a standpoint of survival rate and cost.

### Hoodsport results

PINK						
Year	Number released	Weight	Return			
			Escapement	Catch	Total	S. %
1965	421,000	328/lb	2,236	1,313	3,549	.84
1967	603,000	426	2,256	805	3,061	.51
1969	774,000	323	2,390	1,404	3,794	.49

CHUM						
Year	Number released	Weight	Return			
			Escapement	Catch	Total	S. %
1966	554,000	313	3,008	1969	(Age = 20%	3'0
1967	678,000	295	5,508	1970----	( 79%	4'0
					( 1%	5'0
1968	658,000	379	4,112	1971		

STUDIES OF THE SURVIVAL OF DOWNSTREAM CHUM SALMON FRY  
RELEASED AFTER FEEDING IN A FRESHWATER POND

Ryuhei Sato, Tohoku University, Sendai, Japan

ABSTRACT

Survival rate of downstream tagged and marked chum salmon fry were counted by trap nets at the mouth of Otsuchi River which is flowing into Otsuchi Bay, Iwate Prefecture, Japan. In this experiment, I estimated survival rates of released chum salmon fry and compared survival of smaller unfed with survival of larger fed groups of fish.

The majority of tagged and marked chum salmon fry reached the mouth of Otsuchi River within a night after releasing them on April 11, 1965 from the hatchery which is about 800 meters upstream from the mouth.

In the experiments, survival rate of 99 smaller unfed chum salmon, 36 mm and 0.4 g in average size which were tagged with 198 Au pins and released from the hatchery was counted as 60% during three days. Survival rate of 2-001 marked smaller unfed chum salmon fry released together with the above fish group was 64% during three days.

While survival rate of 119 tagged larger fed chum salmon fry, 50 mm and 1.3 g in average size which were tagged with 60 Co pins and released from the hatchery was counted as 90% during three days. Survival rate of 2,881 marked larger fed chum salmon fry released together with the above fish group was 100% during three days.

The lower survival rate of smaller chum salmon fry seemed to be mainly caused by predacity of some fishes such as "maso" salmon smolts, rainbow trout, gobies and sculpins, because some smaller fry of chum salmon were found in the stomachs of these predatory fishes. However, few larger chum salmon fry have been found in the stomachs of the predatory fishes. Therefore, higher survival rate of larger chum salmon fry seemed to come from such low predacity by predatory fishes.

## LITERATURE CITED

- Hiyama, Y., R. Sato and others. Predation of chum salmon fry during the course of its seaward migration - I. Otsuchi River investigation 1961-1963. (Unpublished).
- Hiyama, Y., R. Sato and others. Predation of chum salmon fry during the course of its seaward migration - II. Otsuchi River investigation 1964-1965. (Unpublished).
- Kanayama, Y. 1968. Studies of the conditioned reflex in lower vertebrates X. Defensive conditioned reflex of chum salmon fry in group. Marine Biol. 2, 77-87. (In Japanese).

Table 1. Predation of chum salmon fry by predatory fishes in 1962 to 1965.  
(Y. Hiyama and others, unpublished).

	Masou salmon	Rainbow trout	Goby	Goby	Sculpin	Total
Numbers of predatory fishes collected	8	2	127	3	52	192
Numbers of salmon fry in the stomachs of preda- tory fishes	15+ $\alpha$	2+ $\alpha$	140	4	72+ $\alpha$	233+ $\alpha$
Numbers of predatory fishes with radio active tags	1	2	12	1	2	18

Table 2. Numbers of the goby, Chaenogobius urotaenia, collected in Otsuchi River (Y. Hiyama and others, unpublished).

Body length	April, 1962		April, 1964		April, 1965	
	Numbers of the goby collected	Numbers of the goby swallowing salmon fry	Numbers of the goby collected	Numbers of the goby swallowing salmon fry	Numbers of the goby collected	Numbers of the goby swallowing salmon fry
21-25 mm			1			
26-30 mm			8		9	
31-35 mm			34		16	
36-40 mm			46		27	
41-45 mm	1		71		22	
46-50 mm	1		46		33	
51-55 mm	3		93	1	35	1
56-60 mm	12	2	65		25	1
61-65 mm	26	9	79	2	20	1
66-70 mm	13	2	50	3	22	4
71-75 mm	12	1	38	1	17	4
76-80 mm	13	3	16	3	13	3
81-85 mm	7	1	13		5	
86-90 mm			3		6	2
91-95 mm	3	1	2		3	1
96-100 mm			2	1		
101-105 mm	1		1			
106-110 mm	1		1	1	1	
Total	93	19	569	12	254	17

Table 3. Numbers of the sculpin, Cottus hangiongensis, collected in Otsuchi River (Y. Hiyama and others, unpublished).

Body length	April, 1962		April, 1964		April, 1965	
	Number of sculpin collected	Numbers of the sculpin swallowing salmon fry	Numbers of the sculpin collected	Numbers of the sculpin swallowing salmon fry	Numbers of the sculpin collected	Numbers of the sculpin swallowing salmon fry
16-20 mm					3	
21-25 mm					8	
26-30 mm					6	
31-35 mm			1		9	
36-40 mm					5	
41-45 mm	2		5		1	
46-50 mm	4		3		4	
51-55 mm	4		8		4	
56-60 mm	3		5		14	2
61-65 mm	2		4		24	15
66-70 mm	3		5		13	8
71-75 mm	2		6	1	7	2
76-80 mm	2		5	1	6	6
81-85 mm	1	1	5	2	2	1
86-90 mm	1		1	1	4	4
91-95 mm			2	2	2	2
96-100 mm			1		1	
101-105 mm	1				1	
106-110 mm	1				1	
Total	26	1	51	7	115	40

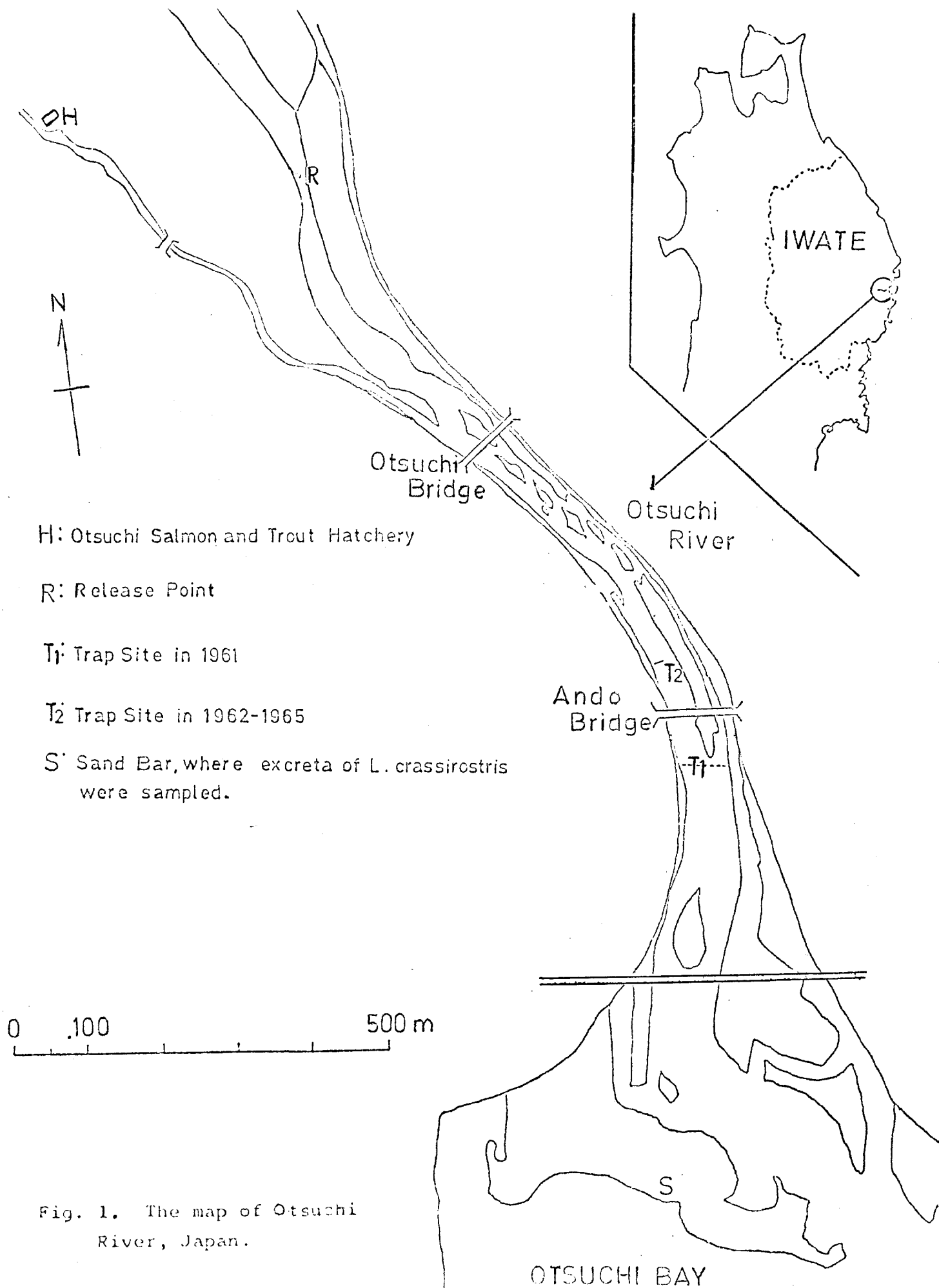


Fig. 1. The map of Otsuchi River, Japan.

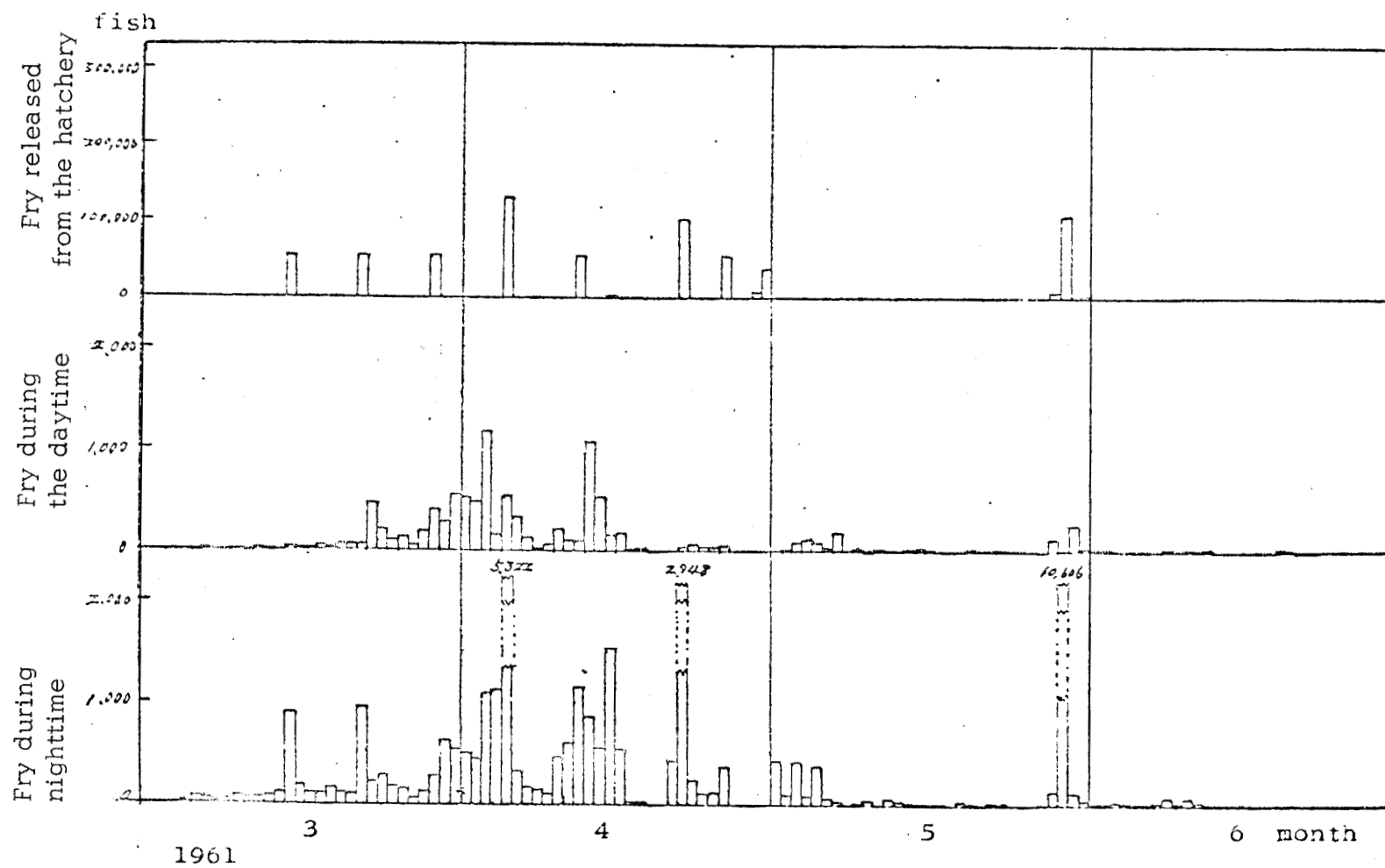


Figure 2. Daily counts of downstream migrants of chum salmon by a trap at the lower Otsuchi River.

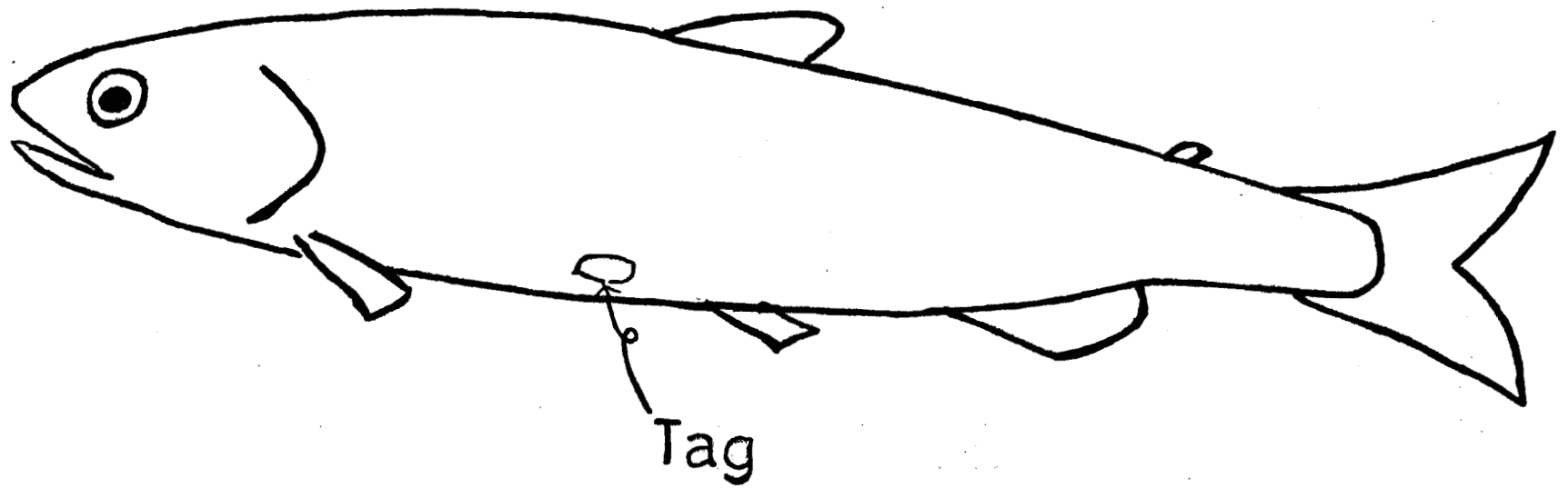


Figure 3. Inserted portion of radioactive tag.

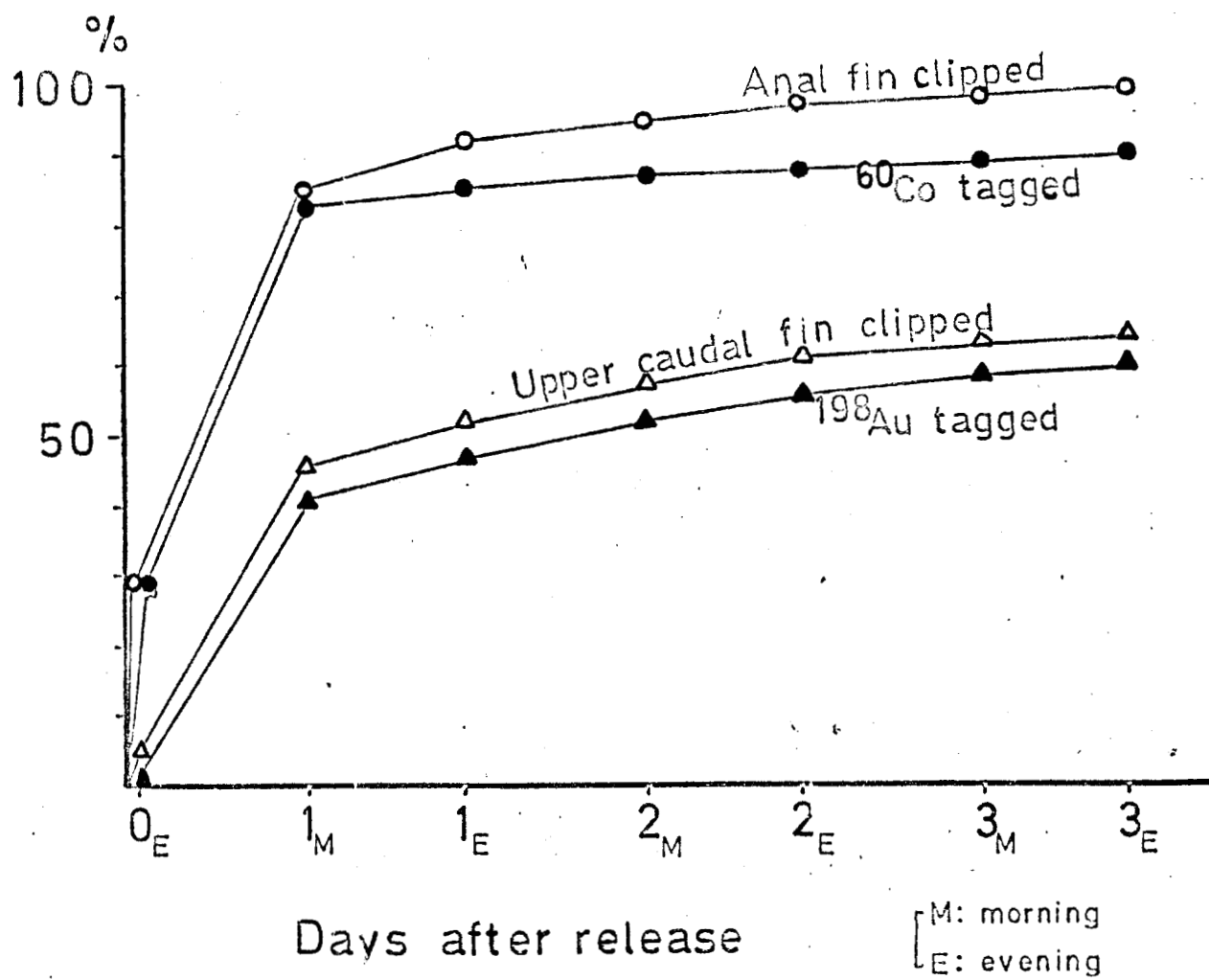


Figure 4. Ratio of the number of descending fry to that of the released (cumulative percentage), 1965.

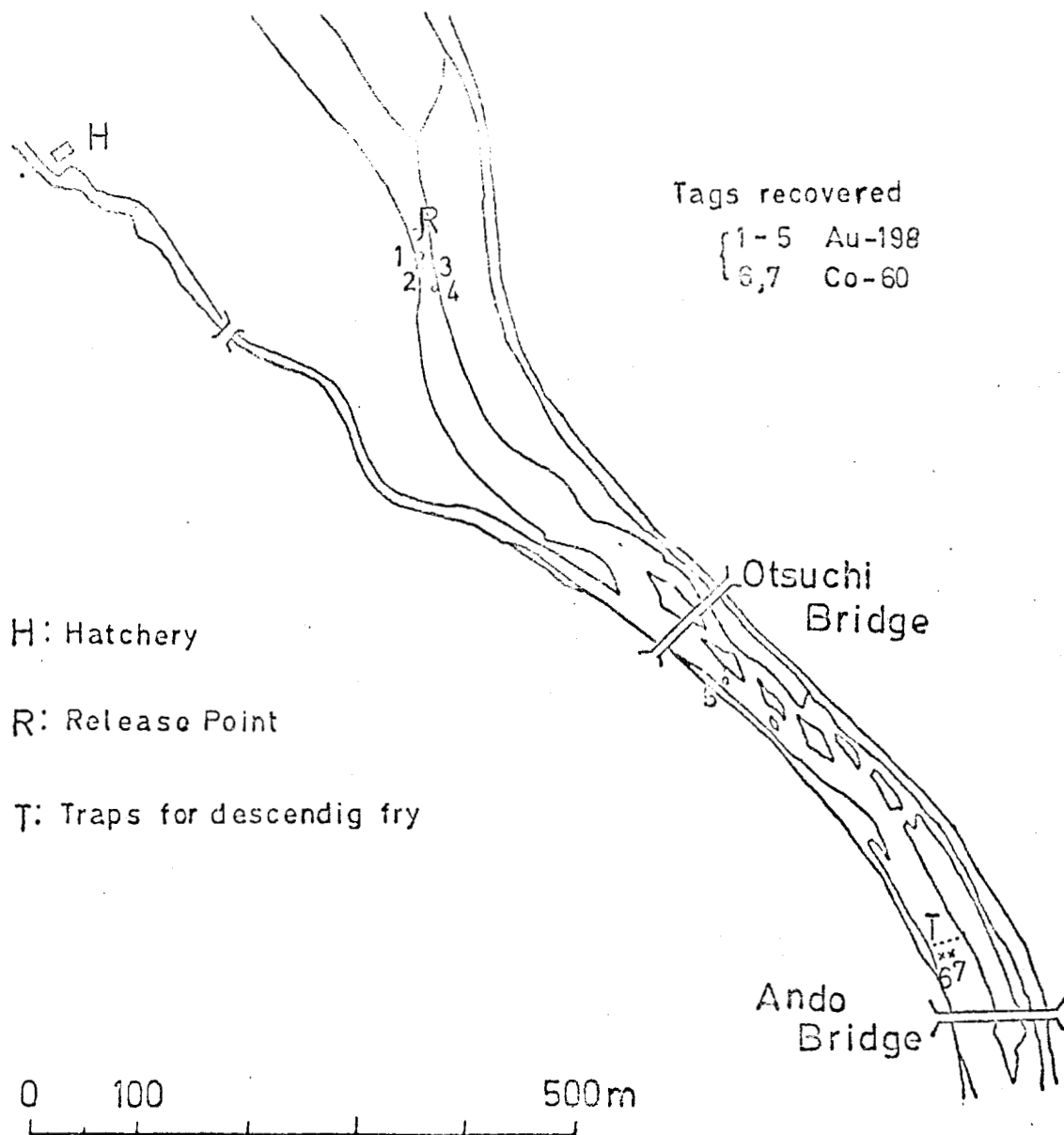


Figure 5. Recovery sites of radioactive tags.

- 1,2: left shore, water depth 25cm
- 3,4: right shore
- 5 : right shore, water depth 10cm
- 6,7: just under traps

## PROGRESS REPORT ON CHUM SALMON PROPAGATION IN OREGON

William J. McNeil, Marine Science Center, University of Oregon

### SUMMARY

Field studies on raising chum salmon in gravel incubation hatcheries are underway at two estuaries in Tillamook County (Netarts Bay and Sand Lake). An experimental hatchery with a capacity to produce up to one million chum salmon fry annually is operated by OSU at Netarts Bay to test hatchery techniques and to evaluate biological feasibility of gravel incubation hatcheries. A commercial demonstration hatchery designed for an ultimate capacity of 20 million chum salmon fry annually is operated by a private firm, Keta Corp., in cooperation with the OSU Sea Grant aquaculture project.

### Background

Construction of an experimental salmon hatchery on a seven-acre site donated by OSU by Mr. and Mrs. Victor A. Swanson was initiated at Netarts Bay in 1968. Machinery and manpower to clear land for the salmon hatchery was donated by the Crown Zellerbach Corporation in 1968. The National Marine Fisheries Service and the Fish Commission of Oregon have provided contract funds to construct hatchery facilities. The most recent addition to our Netarts Bay facility is an advanced prototype of an experimental gravel incubation hatchery designed to produce one million chum salmon fry annually.

The 1971 Oregon legislature established a modern precedent by passing legislation which allows private chum salmon hatcheries to operate under the control of the Fish Commission on certain small coastal streams. The first private hatchery to be constructed under the new law is located at Sand Lake about 10 miles south of the OSU experimental hatchery at Netarts Bay. It is owned and operated by Keta Corporation, and we propose to use this production facility as a Sea Grant demonstration project. Additional private hatcheries are in planning for the Oregon coast, and the OSU hatchery at Netarts Bay will sell surplus chum salmon eggs to Keta Corporation and future chum salmon farmers. Funds received from the sale of eggs go to the State General fund.

We expect to release 230,000 1971 brood year chum salmon juveniles from our Netarts hatchery in spring 1972. Releases in earlier years included pink, chum, and Chinook salmon and are summarized in the following table:

Species (Source)		Brood year	No. of fry	No. of fingerling	Period of emigration
Pink	(Alaska)	1968	7,000	0	Jan. '69
Pink	(Alaska)	1969	393,000	0	Dec. '69-Mar. '70
Pink	(Alaska)	1970	223,000	0	Dec. '70-Mar. '71
Chum	(Oregon)	1969	175,000	50,000	Mar. '70-May '71
Chum	(Oregon)	1970	451,000	30,000	Feb. '71-May '71
Chinook	(Washington)	1969	0	75,000	May '70
Chinook	(Washington)	1970	0	40,000	May '71

### Status of Research and Development

The prototype hatchery at Netarts Bay is constructed of 4' x 8' wooden tanks. The eggs are hatched on screened trays which overlie a bed 1/4" to 3/4" crushed rock. The alevins develop on the rock substrate, and pink and chum salmon fry leave the hatchery on their own volition through drain pipes. Water velocity is held at about 100 cm/hr in the hatchery tanks to simulate velocities in good quality spawning gravels. The tanks have lids to exclude light.

Water quality problems have arisen from sedimentation and biological growths. Sedimentation problems are controlled by a large settlement pool. Biological growths are not detrimental provided we avoid using a deep bed of gravel and overcrowding of eggs and alevins. An advanced prototype hatchery was constructed in summer 1971 where eggs are hatched on four vertically stacked trays at a density of about 500 per ft.<sup>2</sup> Alevins repose on a 3/4" deep bed of crushed rock.

Pilot production to date includes the release of 623,000 pink salmon from Alaska and 115,000 Chinook salmon from Washington. The Alaska pink salmon were obtained from Southeastern Alaska with the assistance of the National Marine Fisheries Service and the Fish Commission of Oregon. Chinook salmon came from the University of Washington and were released with the approval of the Fish Commission of Oregon. There are no plans to undertake additional transplantations of pink salmon, but additional Chinook salmon seed stock may be requested from the University of Washington.

Juvenile Chinook salmon exposed to water of low salinity experienced low mortality when transferred to water of high salinity, but their growth was slowed. Experiments are continuing to determine the size at which Chinook salmon can be transferred to water of high salinity without affecting growth.

Pilot production of Chinook salmon at Netarts Bay is intended to obtain information on marine survival of Chinook salmon released after short-term rearing in combination with acclimation to sea water in hatchery ponds.

Much of our laboratory research is designed to compare quality of juvenile salmon from standard incubators with those from gravel incubators. It is well known that fry from gravel incubators are larger than those from standard hatchery incubators. For example, 1970 brood year pink salmon fry from a heath incubator at the Netarts Bay hatchery averaged only 30 mg dry weight in comparison to 45 mg dry weight for fry from a gravel incubator. But perhaps of greater significance is the discovery that pink and chum salmon alevins from hatchery incubators exhibit a high incidence of malformed yolks; whereas, those from gravel incubators exhibit a low incidence.

The malformation appears as an elongation of the posterior margin of the yolk which accompanies the formation of a fluid-filled vesicle covered with scar tissue. We tentatively attribute this condition to mechanical abrasion which causes blood vessels on the surface of the yolk to rupture. We commonly observe the condition in pink and chum salmon alevins in standard incubators and rarely in alevins from gravel incubators. The condition appears to cause high delayed mortality and may impair growth after initiation of feeding.

In one experiment, where pink salmon fry from a Heath incubator were compared with fry from a gravel incubator, total survival from hatching to 75 days after yolk absorption was only 37% for Heath incubator fish and 88% for gravel incubator fish. Average wet weight of the fish surviving after 75 days of feeding on an unrestricted diet was 4.2 grams for Heath incubator fish and 6.5 grams for gravel incubator fish.

The significance of our salmon research will depend upon marine survival and return of hatchery chum salmon to Netarts Bay. Sampling of wild fry in the hatchery stream (Whiskey Creek) indicates that the hatchery produces between 10 and 20 fry for every wild fry produced. Our expectations is for at least a one percent marine survival of the hatchery fry, and we will begin to evaluate this expectation in November 1972 when three-year-old fish from the 1969 brood year return to Netarts Bay.

There were no returns of either 1968 or 1969 brood year pink salmon to Netarts Bay. We made no predictions on the possibility of returning pink salmon because the return of adults may be adversely affected by early entry of fry to the ocean (December-March) low summer stream flows in the hatchery stream, and transplantation to a stream mouth of the natural range of pink salmon spawning populations.

Also, there were no returns of two-year-old male Chinook salmon in autumn 1971. As with the pink salmon, the potential for returning Chinook salmon to Netarts Bay is thought to be less assured than with the native chum salmon.

#### Future Plans

By spring 1973 we hope to increase release of chum salmon at Netarts Bay to approximately one million fry annually. The release of one million fry in 1973 is dependent upon the return of three-year-old 1969 brood year hatchery fish in November 1972. Experiments to compare the growth and survival of fry from gravel incubation hatcheries and from standard hatcheries will continue at Netarts Bay with pink and chum salmon in 1972. Duplicate experiments are planned simultaneously with pink salmon at Little Port Walter, Alaska, in cooperation with the National Marine Fisheries Service Coastal Center, Auke Bay, Alaska.

Routine production of Chinook and/or pink salmon will be continued at Netarts Bay provided we obtain adult fish from the releases already made. It was mentioned earlier that no pink salmon returned in 1971, but we will await possible returns in 1972 to determine if we will continue to produce pink salmon at the Netarts hatchery. However, the outlook is not encouraging for pink salmon. Our first mature female Chinook salmon should return in autumn 1972.

Any surplus chum salmon spawners returning to Netarts Bay in autumn 1972 and later years will be made available for sale to private hatcheries in Oregon at \$2.00 per thousand eggs. Before we declare fish to be surplus, we will retain 1.2 million eggs for the Netarts hatchery and release sufficient females into the hatchery stream, Whiskey Creek, to provide a natural spawn deposition of 0.5 million eggs. Fry from natural spawning will be used in laboratory and field experiments comparing hatchery with natural fry.

The first 1.0 million eggs sold from our hatchery at Netarts Bay in 1972, 1973, and 1974 will be used to stock the Keta Corporation hatchery at Sand Lake. Stocking of the Keta Corp. hatchery and other future commercial hatcheries will continue for three years for each hatchery. In the fourth year, individual commercial hatcheries should have their own runs of fish, provided the concept of the gravel incubation hatchery is biologically sound.

# SOME PRELIMINARY OBSERVATIONS ON POSSIBLE INDICES OF PINK AND CHUM SALMON FRY QUALITY

Derek C. Poon, Marine Science Center, Oregon State University

## INTRODUCTION

Quantifiable quality testing of salmon fry is becoming an important tool for management and research in fish culture. At OSU, one general goal of the pink and chum salmon program is to define the incubation methods best suited for us with unfiltered water. To evaluate fry produced from our test systems, a number of fry quality indices have been tried.

Fry quantity has been investigated by many workers, notably Mr. Burrows and co-workers at the Longview Salmon Culture Lab in Washington and Mr. R. Bams of the FRBC at British Columbia. In selecting our own criteria, we drew both from established techniques and from our own experimentation. This report presents some preliminary observations on our attempts at quantifying fry quality.

The data presented here are mostly from the work of the last field season, which was devoted to the comparison of the Heath incubator fry versus the OSU Streamside incubator fry. From last year's data we derived a program of fry quality analysis for this year's study, which is extended to compare five incubation systems: the Heath incubator, the hatchery trough, the Streamside incubator (1" layer of 1/4" crushed rock substrated; alevin are incubated above the substrate), the deep gravel incubator (5" of 1/4" to 3/4" crushed rock substrated; alevins incubate in the substrate, and the natural stream bed. The present study is in progress in two locations - OSU's Netarts Aquaculture Lab and NMFS's Little Port Walter Research Station in Southeastern Alaska.

### Fry Quality Analysis

Fry quality analysis is conducted within the period from hatching to about 60 days after button-up. Measurements taken are of 2 general categories: 1) measurements of physical characteristics, and 2) measurements of performance in stress tests.

### Measurements of Physical Characteristics

Under this category, measurements taken are wet weight, dry weight, and length. These measurements are used for the determination of 2 parameters: 1) the maximum size at button-up, and 2) the ability for the fry to feed and grow for up to 60 days after button-up.

Maximum size at button-up will indicate whether the incubation environment minimized the loss of potential size due to activities other than growth. With the development by Mr. R. Bams of the developmental index

$$(K_d = \frac{10^3 \sqrt{\text{wet wt. in mg}}}{\text{length in mm}}) \quad \text{which can sensitively identify the stage of yolk}$$

absorption, comparisons of measurements between groups of fry can be made by converting to values at identical  $K_d$  stages. Our data basically concurred with previously reported results, that gravel incubation (with the streamside incubator) minimizes the loss of potential size to premature activities. The gravel fry have consistently averaged over 15% larger than the comparable heath incubator fry. Information will be forthcoming on the 5 incubation systems being tested.

The ability of the fry to feed and grow seems to reflect its early incubation history. Our experiments have produced within 60 days a discernible difference between heath incubator and streamside incubator pink and chum fry. We observed in the heath incubator fry not only a lower growth rate, but also an associated higher incidence of non-feeding pin-heads, as evidenced in a bimodal or skewed population distribution in weight and length. Both factors of growth rate and population distribution will be charted in this year's experiments.

### Measurements of Performance in Stress Tests

Our studies basically utilize 2 stress tests: 1) the swimming performance test run at various D.O. levels, and 2) an anoxia test consisting of the physical removal of the fry from the water for a standard length of time. We have not yet conducted the swimming performance test but some pilot anoxia tests were run with encouragingly sensitive and repeatable results.

In one anoxia test this year, pink salmon fry from 3 sources -- streamside incubator, heath incubator tray, and gravel-lined heath incubator tray -- were tested. One hundred fifty fry from each source was divided into 3 equal groups of 50 fry. The fry were removed from water for 30 minutes and then placed into the water. After a recovery period of 24 hours, the number of mortalities from each triplicate of 50 fish were: 17, 14, 12 or a total of 43/150

for the heath group; 5, 6, 6 or a total of 17/150 for the gravel-lined heath group; 1, 2, 4 or a total of 7/150 for the streamside incubator group. These fry were at approximately the same  $K_d$  stage, were from the same initial stock of eggs, and had identical thermal history.

## CONCLUSION

Allow me to emphasize that this report presented preliminary observations, and that the data are not all in. We are hopeful that the above format of fry quality analysis will give us the necessary information with which to rate the 5 aforementioned incubation systems, and that we may present in some future date our cumulative results.

A SUMMARY OF THE SPAWNING CHANNEL RESEARCH BY F.R.I. AS  
RELATED TO THE EFFECTS OF GRAVEL COMPOSITION AND SPAWNER  
DENSITY SUCCESS, EMERGENCE SURVIVAL, AND FRY QUALITY

K.V. Koski, Fisheries Research Institute, University of Washington

Research is being conducted by use of the experimental channel at the University of Washington Big Beef Creek Research Station for determination of the gravel composition that will produce the optimum number of chum salmon (Oncorhynchus keta) from egg deposition to emergence as well as produce the highest quality of fry. Quality, in this case, is defined as those characteristics of the embryos and fry that will give them the greatest viability and ultimately the highest return as adults. Two spawning channels were constructed in such a manner that some of the ecological factors affecting the success of salmonid spawning could be manipulated. At present the first channel (Figure 1) is divided into 24 sections of four different gravel mixtures (i.e., varying percentages of gravel and sand) and is used for the study of the effects of gravel composition. A second adjoining channel consists of 12 separate sections of one type of gravel and is used for the study of the effects of different spawning densities. Weight, length, and age of each adult salmon placed in the channels are recorded and the fish are identified by a numbered tag. Spawning behavior, longevity, and spawning success (i.e., number of eggs and milt retained) are recorded. Calculated fecundities and male gonad weights are used for determination of the potential spawning capabilities of each individual spawner.

Preliminary analysis of the data in 1969 showed an inverse relationship between the amount of gravel fines and the survival rate among chum salmon from egg deposition to emergence (Figure 2). As illustrated, the survival rate to emergence among fry spawned in the gravel mixtures with comparatively higher percentages of fines (3.327 mm) were much less than among the fry from the other gravel mixtures. Analysis of the same data also showed that the weights and lengths of these fry were comparatively less (Table 1).

Much emphasis has been placed on defining natural variability in the quality of emerging fry, determining indexes of quality, and isolating the main factors responsible for the variability. Fry reared under the various ecological conditions in the channels were observed to differ by up to 10 mm in length (range 32 mm to 42 mm) and to vary up to 100 percent in body weight (range 0.20 g to 0.40 g). Norms are being established with regard to fry quality by measurement of the following parameters:

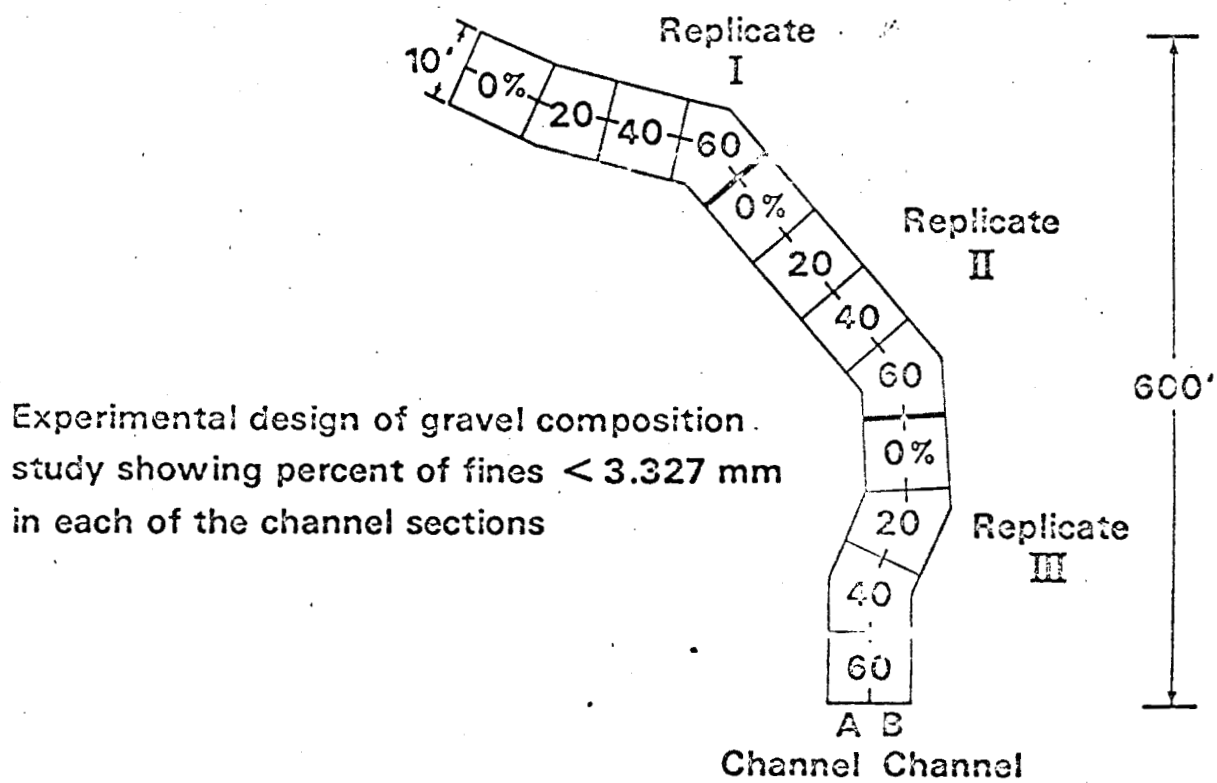


Figure 1. Experimental channel.

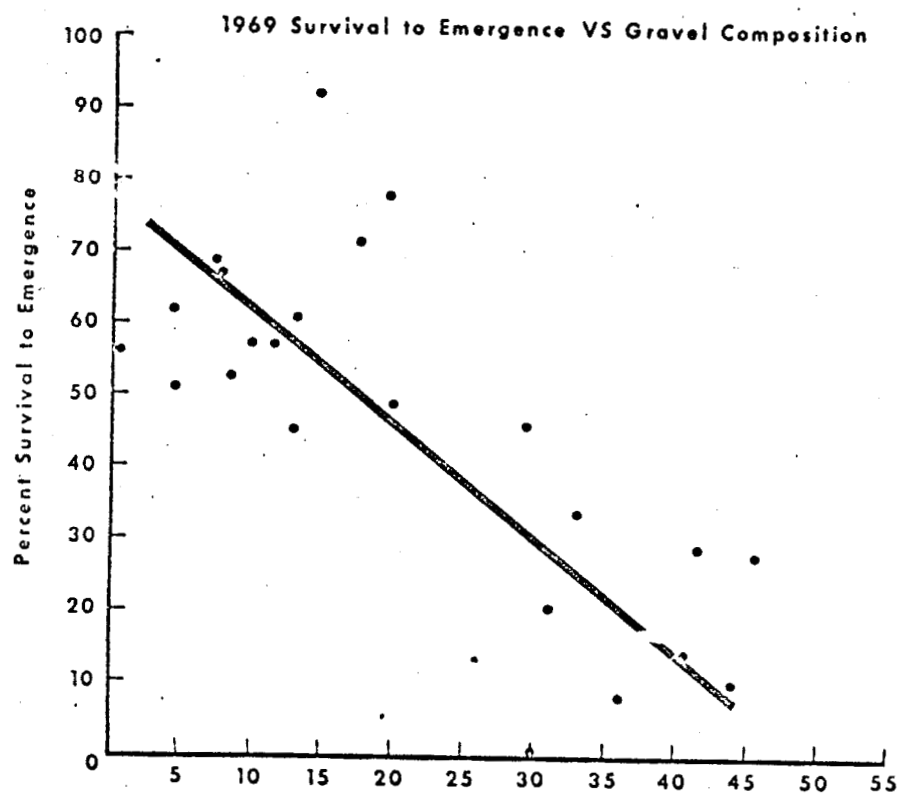


Figure 2. Percent gravel fines less than 3.327 mm.

Table 1. Summary of 1969 chum emergence for replicate 3 of spawning channel.

Channel section	% gravel comp.	No. ♀ spawners	Mean ♀ weight (lbs)	Mean ♀ length (mm)	Total number of fry emerged	% fry survival	Mean fry weight (live)	Mean fry length (live)
III-1-A	7.3	5	8.9	694	11,462	68.8	0.374	39.12
III-3-A	20.1	5	10.2	734	9,201	49.3	0.358	39.14
III-2-A	31.1	6	10.1	717	4,367	20.4	0.343	38.53
III-4-A	44.0	4	10.1	732	1,420	10.1	0.335	37.99

- (1) egg size and parent influence
- (2) fry morphometrics (length, weight, width, depth, and computed condition factors)
- (3) quantity and quality of lipids
- (4) stamina and swimming performance
- (5) predator avoidance

During 1969 and 1970, chum salmon were placed in sections of the spawning channel in densities ranging from 0.125 females/m<sup>2</sup> to 0.75 females/m<sup>2</sup>. The number of fry produced to emergence increased with increasing number of spawners so that it was highest in the section with the greatest density of spawners (Figure 3). On the other hand, the percentage survival to emergence (AED) decreased slightly with the increasing number of spawners. However, preliminary analysis indicates a significantly poorer "quality" of fry with the greater densities of spawners. The significance of this reduction in quality is being analyzed by predator-prey tests and by growth experiments in brackish water.

The effects of density on the spawning behavior and spawning success being studied to determine whether any behavioral anomalies can be associated with increasing densities. Through analysis of these anomalies, optimum stocking densities and changes in channel design can be made for procurement of optimum fry production.

The salmon are placed in 10' x 50' subsections of the spawning channel in specific densities at a sex ratio of 1:1. Spawning success is measured in terms of egg retention, male gonad weights, longevity, and behavioral observations.

The experiments have shown an increase in the total number of eggs retained per channel section with increasing density of spawning females (Figure 4). Observations are conducted on the spawning behavior to seek patterns influencing egg retention and to explore ways in which the inefficiency can be corrected.

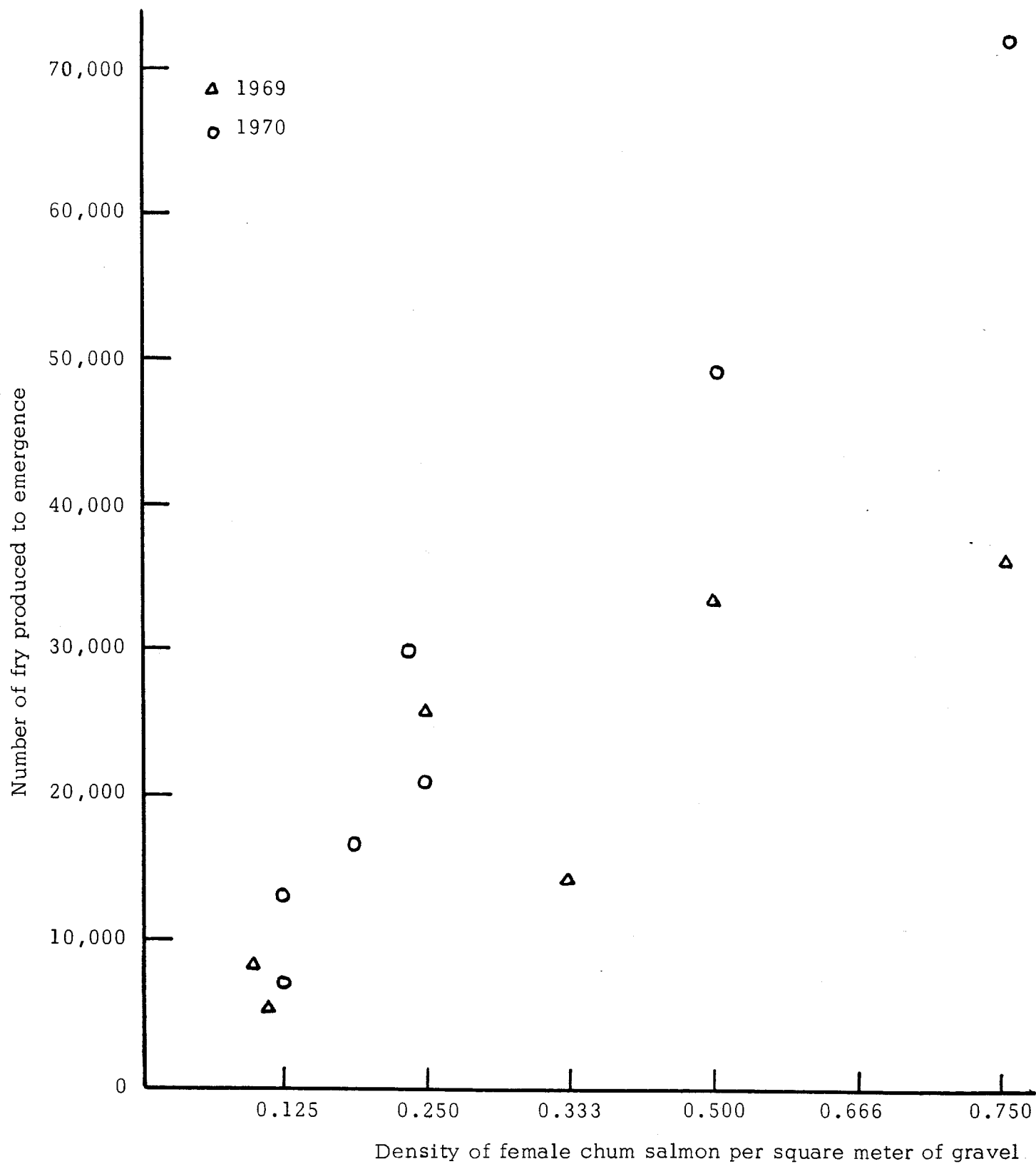


Figure 3. Relationships of spawner density to number of fry produced in Big Beef Creek spawning channel.

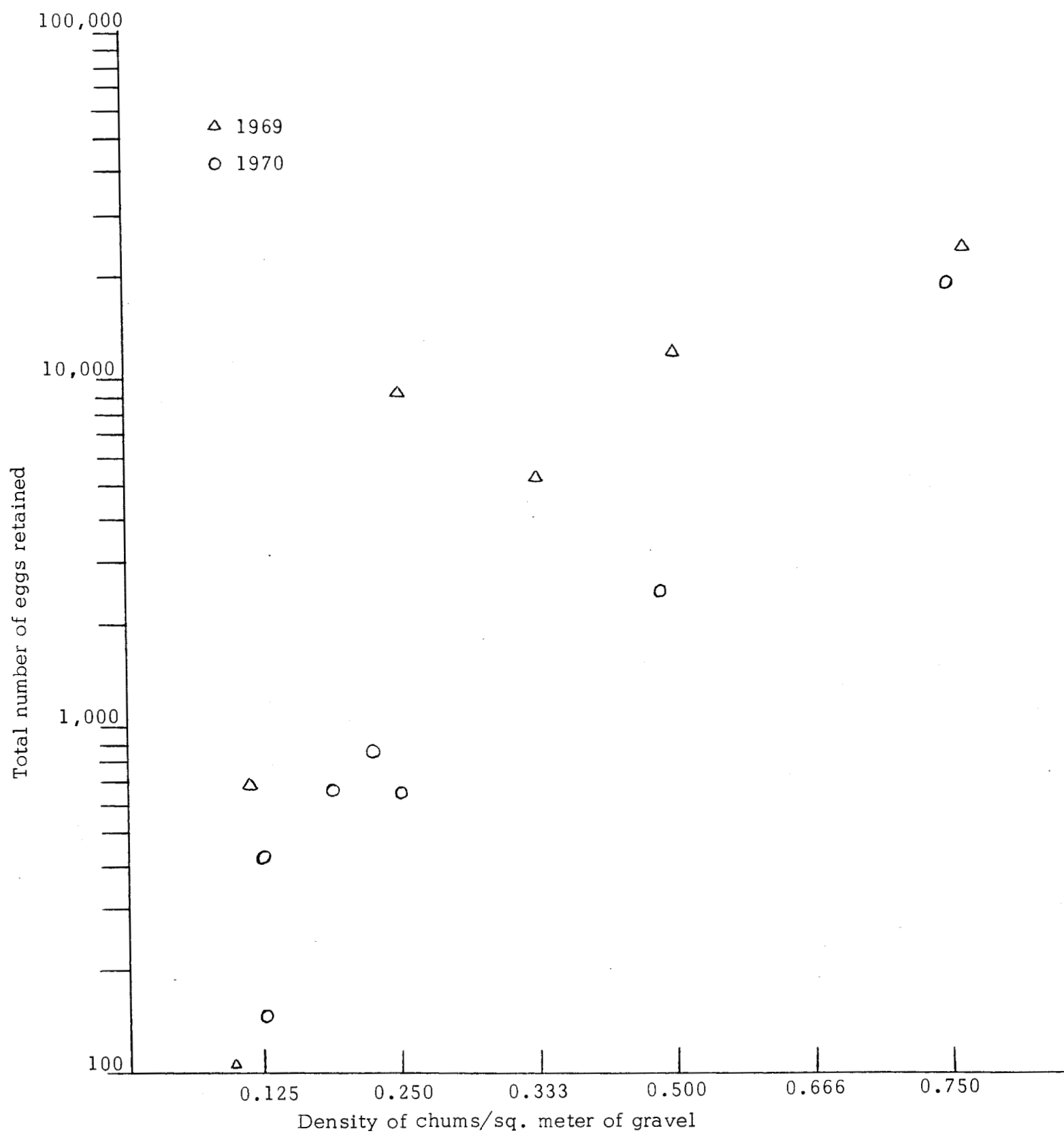


Figure 4. Relationship of spawner density to total egg retention in Big Beef Creek spawning channel.

EFFECTS OF DENSITY ON THE SPAWNING SUCCESS OF CHUM SALMON  
(ONCORHYNCHUS KETA)  
- A PROGRESS REPORT -

Steve Schroder, Fisheries Research Institute, University of Washington

ABSTRACT

The effect of density on the spawning success of chum salmon (Oncorhynchus keta, Walbaum) was examined at Big Beef Creek during the autumns of 1969, 1970 and 1971. The densities examined ranged from .036 to 1.50 females/yard<sup>2</sup>. It was found that the greater the number of females/yard<sup>2</sup> or substrate, the greater the average egg retention per female. Lack of female spawning success was found to be caused in part by inter- and intra-sex aggression, physiological ripeness, territoriality of the species, and environmental factors. Male success (percentage of the entering gonad weight used in spawning) was not influenced by density. It was influenced, however, by physiological ripeness, ability to use the "right" spawning strategy at the right time, and environmental factors.

INTRODUCTION

Part of the research conducted at Big Beef Creek during the past three years has concerned itself with the effects of density on the spawning success of chum salmon. This research was conducted using a spawning channel 600 ft long and 20 ft wide. The channel is made up of three parallel subchannels. Subchannel "C", which is 10 ft wide and segmented into twelve 50 ft sections, was used in the density experiments.

Density was defined as the number of females/yard<sup>2</sup> of available spawning substrate. During the three autumns, densities ranged from 1/28 of a female/yard<sup>2</sup> to 1-1/2 females/yard<sup>2</sup>. The data gathered indicates a relationship between density of spawning females and egg retention. The greater the number of females/given substrate area, the greater the average number of eggs retained/female (Figure 1).

PROCEDURE

Mature chum salmon were captured at either of two traps located at

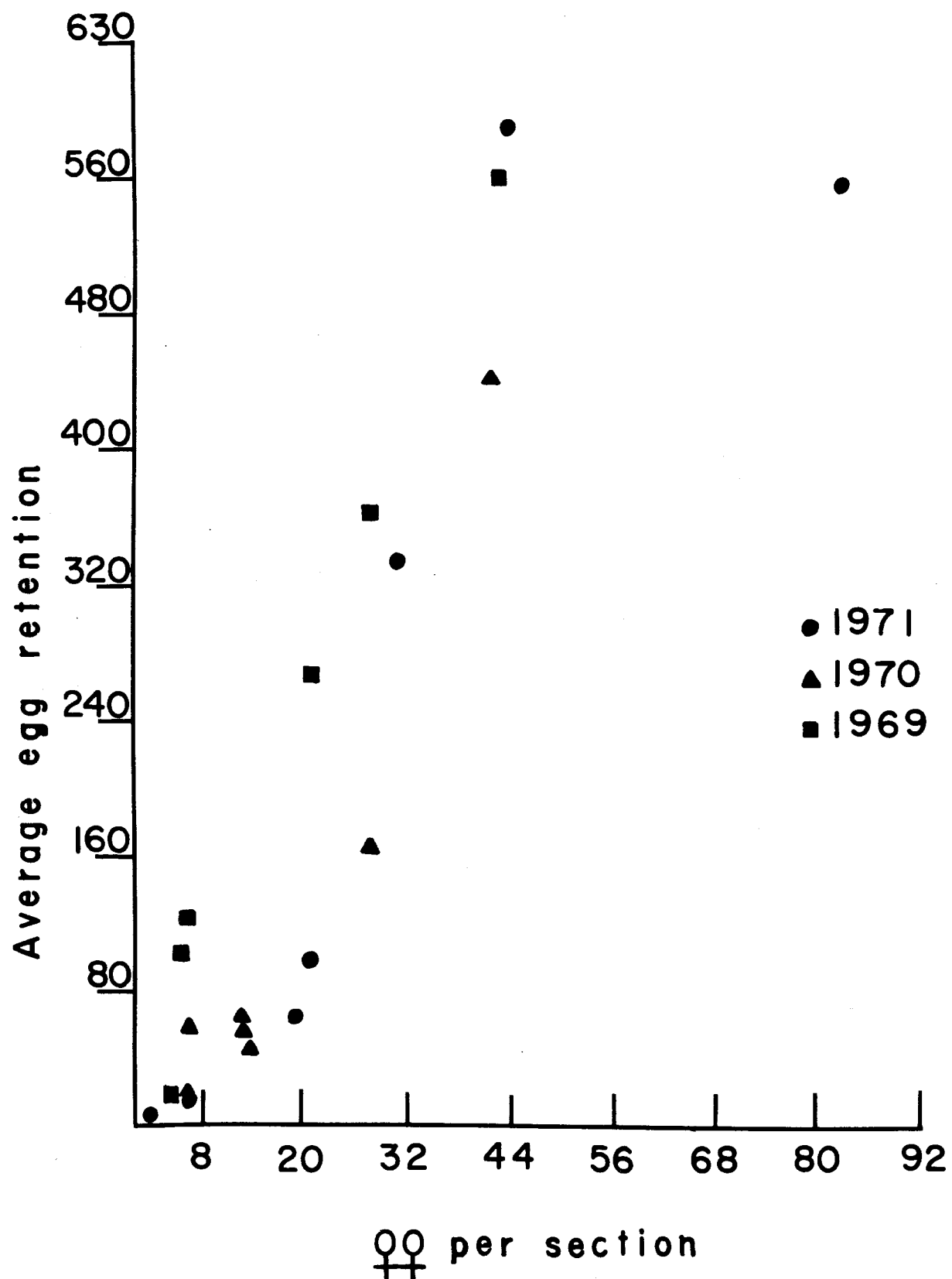


Figure 1. Relationship between density of females and average egg retention.

the mouth of Big Beef Creek. Length, weight, physical appearance, sex, and age were recorded for each experimental fish. To aid in behavioral observations, the fish were tagged with color-coded Peterson discs. Each density section was filled within 3 days to suppress the effect of redd suprainposition and to maximize the effects of density on spawning behavior.

Female success was determined by the number of eggs retained after death. The fewer eggs retained, the more successful a female was considered to be. Male success was defined as the percentage of the entering gonad weight used during spawning. The greater the percentage used, the more successful the male.

Ten-ft-high walls were erected on the outside wall of the channel sections used in the density experiments. These walls were provided with windows to allow close observation of spawning behavior without disturbing the fish. Each density section also had a 16-ft-high observation tower erected either in the middle or at one end of the section. These towers were used primarily to map redd locations.

Behavioral observations were conducted on a 2-hr on and 2-hr off cycle. These observations were restricted to courting activities and the interactions of paired fish with their neighbors. Other observations were conducted to determine specific redd, and individual fish locations, spawning longevity, and egg and milt retention.

#### FEMALE SUCCESS

The above observations have led to a tentative understanding of the mechanisms involved in egg retention. In any given section, there were some females who were not ready to spawn immediately. Instead of establishing redd sites, these females remained in the upper portion of their sections, usually swimming against the picket barrier. At low spawning densities, unexploited gravel space was still available to these late ripening females. However, in high density sections, females of this type were confronted with a territorially bound system when they were ready to spawn. If a late-ripening female was unable to evict a prior resident female or establish a territory between prior resident females, she became a nomad and was evicted from territory to territory in her section. This type of female usually died with a full complement of eggs. Not all late-ripening females were of this type; many of them were able to evict weakened, partially- or totally-spent prior resident females, or establish a redd territory between prior resident females. The evicted females became nomadic and were usually unable

to spawn again. The process of defending and/or evicting is an energy drain, and may very well increase egg retention.

In general, in the densities examined, aggression between females increased as the density of females increased. A female can be attacked by neighboring fish of either sex, being most susceptible to female aggression while she is digging. Continued attacks on digging females can delay pocket construction as well as weaken the interacting fish. In the highest density section (1.5 females/yard<sup>2</sup>), repeated attacks made by neighboring females greatly inhibited post-spawning digging. Usually, the first post-spawning activity of a female is to bury her eggs. If she is inhibited from doing this, there could be potential predation on the newly-deposited eggs. Another consequence of this aggression was a decrease in redd size. Females were seen to deposit eggs two to three times in a single pocket, after burying the preceding deposit of eggs slightly.

A female's success cannot always be determined by the number of eggs she retains. Females which spawn immediately and die leave their redd territories undefended and exploitable to newly-matured or arriving females. In one high density section, three females in succession were observed to spawn in the same area. The two preceding females' eggs were probably destroyed by mechanical injury. Redd suprainposition then can disguise female success based on egg retention.

Asocial factors such as water depth, velocity, temperature, and the physical condition of the female, also effect egg retention.

## MALE SUCCESS

In the autumns of 1970 and 1971, data was collected on the spawning success of males experiencing different densities. Density, in this case, was defined as the number of males/given substrate area. During the two years, densities ranged from .036 to 1.13 males/yard<sup>2</sup>. It was found that the densities experienced by these males had no effect on their spawning success (see Figure 2).

The criteria used in judging male success was the percentage of the entering gonad weight used during spawning. In 1970 and 1971, linear regression lines were developed to predict entering male gonad weights. Males from Finch Creek, an ecologically-similar stream to Big Beef Creek, were sacrificed before they had spawned. Condition factors, weights, and lengths, were determined for each male and plotted against their gonad weights. Total

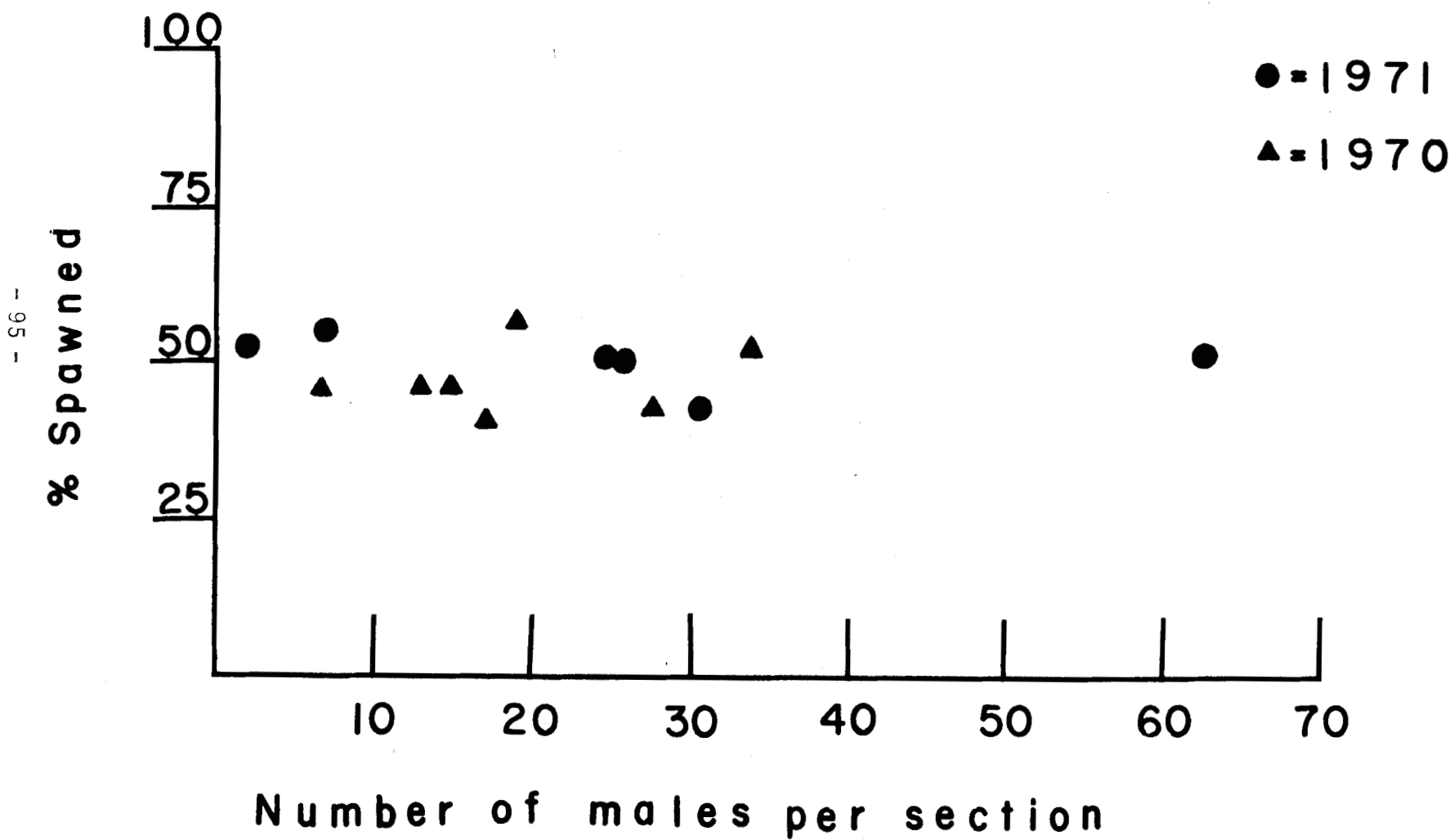


Figure 2. Relationship of density between males and percentage of entering gonad weight spawned.

body weight proved to be the best predictor for entering gonad weight.

The slopes (1970, .0309; 1971, .0320) and correlation coefficients (1970, .826; 1971, .864) of the regression lines proved to be similar. The data were then combined and the resulting regression formula obtained was used in predicting entering male gonad weights (Figure 3).

Several physiological factors could influence the quantity of gonadal tissue retained, two being spermatogenesis and reabsorption of gonadal tissue on the spawning grounds. An experiment was conducted to determine the effect these factors had on the amount of male gonadal tissue retained. Males were placed in channel sections without females, and these fish were stripped periodically, or not at all. The result of this experiment indicated two things:

- (1) Spermatogenesis and reabsorption were not important factors in Big Beef Creek males, and
- (2) the more times a male was stripped, the greater the percentage of his gonad tissue that was used, (Figure 4).

Males employ three basic types of spawning strategies:

- (1) Courting and maintaining a territory around one or more females from the beginning of pocket construction until spawning,
- (2) cruising throughout the spawning area seeking females with nearly completed pockets, and
- (3) maintaining a satellite territory in back of a courting pair and contributing during the spawning act.

The type of strategy employed depends upon the male's ability to establish and maintain a territory around a female. This ability is reflected in the male's size, state of deterioration, and number of competing males around him. Females may also influence strategy selection by their preferences for similarly-sized and aged males (Hanson and Smith, 1967).

Male success does not depend upon the strategy employed. All types appear to be equally successful, and the males are capable of shifting into different types through time. Lack of success is strongly influenced by the ripeness of the male and the availability of ripe females with which to spawn. It is also influenced by the male's ability to use the "right" strategy at the right time.

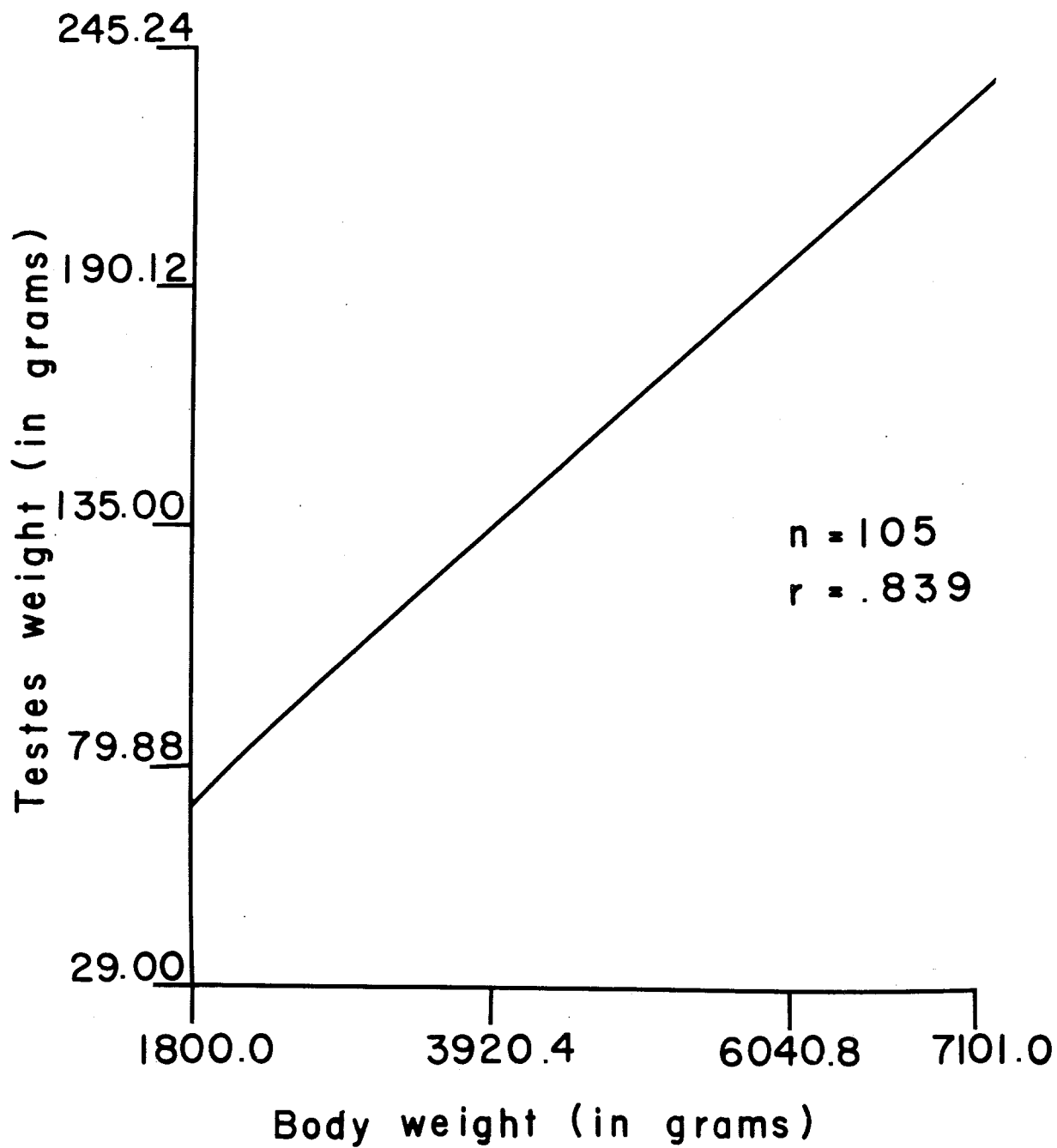


Figure 3. Correlation between body weight and testes weight in unspawned chum salmon.

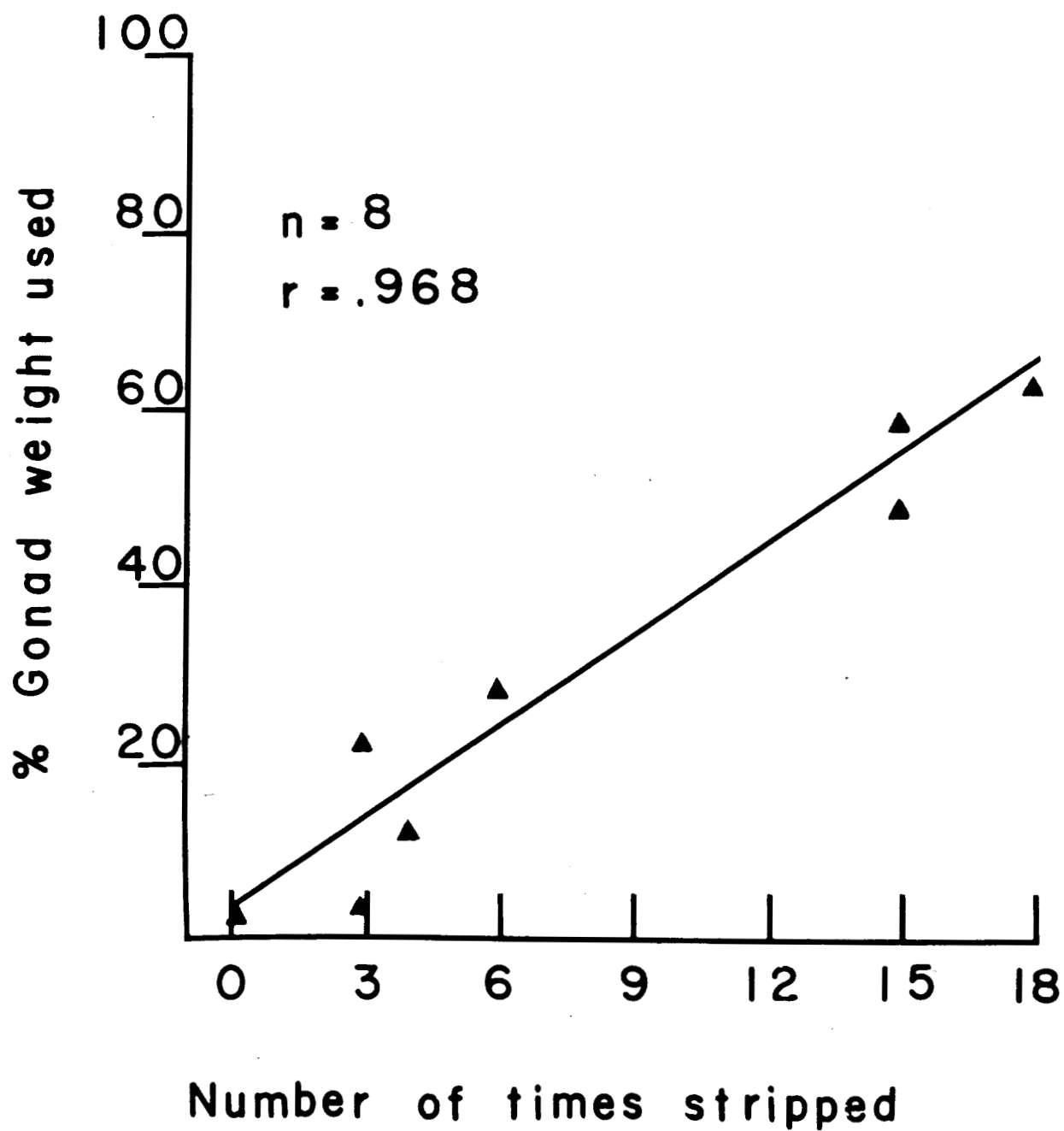


Figure 4. Correlation between gonad weight and number of times male had been spawned artificially.

The establishment of male territories is often accompanied by ritualized fighting behavior. This type of fighting consists of lateral displays, physical contact, and often, inversion behavior (male digging). Females are often evicted from their pockets by this type of fighting. In high density sections, they are then susceptible to attack by neighboring fish of either sex. These attacks may contribute to the high egg retentions experienced in these sections.

## DISCUSSION

Suggestions can be made which may increase male success and decrease egg retention. Strictly in terms of egg retention and redd supposition, it appears that .25 to .30 females/yard<sup>2</sup> is the ideal family density.

By making several assumptions, a sex ratio can also be suggested. These assumptions are that:

- (1) Females deposit between 500-600 eggs per pocket and hence, on the average, spawn five to six times,
- (2) 80-85% of the entering gonad weight of a male can be used for spawning, and
- (3) the percentage of gonad weight used in the stripping experiment is comparable to that which is used in natural spawning.

If these experiments hold true, then a sex ratio of four females to one male is recommended.

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# SALTWATER AND FRESHWATER POND REARING OF CHUM SALMON

Ryuhei Sato, Tohoku University, Sendai, Japan

## ABSTRACT

Chum salmon reared in freshwater and saltwater ponds to the third fall from hatching, and growth, survival rate some blood properties were compared between these two fish groups.

2,250 and 2,994 fry of chum salmon, Oncorhynchus keta (Walbaum), were put into saltwater and freshwater ponds respectively at a controlled water temperature below 19 C and fed on various fresh fishes and a dry mixed ration for three years.

The average length and weight of the saltwater fish group was 255 mm and 220 g by the first fall, 397 mm and 962 g by the second fall and 530 mm and 1,950 g by the third fall. Some male fish of the saltwater group matured by the second and third fall and the female fish of this group also matured by the third fall. The average length and weight of the freshwater fish group was 182 mm and 83 g by the first fall and 237 mm and 242 g by the second fall. The growth of this fish group, however, was small in the third year. A few male fish of the freshwater fish group also matured by the second fall.

The average ratio of weight in grams to length in centimeters of the body of the saltwater fish group was 23.7 and 34.7 in the second fall and the third fall respectively. That of the freshwater fish group was 10.2 and 13.8 in the second fall and the third fall respectively.

Cumulative percentage mortality of the saltwater fish group was low in the second and third years though it reached 75% the first fall owing to a bacterial disease. That of the freshwater fish group was 9% and 45% at the first and second falls respectively. However, the third fall mortality rate was 98%.

The average water content in the blood of the saltwater fish group was 77.8% and 81.3% in the second fall and the third fall respectively. That of the freshwater fish group was 86.9% and 94.7% in the second fall and third fall respectively.

In other experiments performed by Iioka (1970), 180 and 10,400 chum salmon fry were reared in saltwater and freshwater ponds and they grew to

46.9 g and 82.9 g respectively at the first fall. The mortalities of them was 15.5% in the saltwater pond and 87.1% in the freshwater pond under the controlled water temperature, 10.5-18.8 C, during the first year. 262 and 969 chum salmon fry were also reared in the two saltwater ponds under the natural water temperature, 6.9-22.0 C, and they grew to 40.0 g and 38.9 g respectively at the first fall. Their mortality was 71.4 and 49.8% and many of the fish died immediately after high water temperature in the summer season of the first year.

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Table 1. Growth of the kidney of the chum salmon reared in the salt water and fresh water ponds.

Age	Salt Water			Fresh Water		
	Body weight (g)	Kidney weight (g)	ratio (%)	Body weight (g)	Kidney weight (g)	ratio (%)
The first year Sep. (6 months)	7	0.07	1.00	9	0.09	1.00
The second year Mar. (12 months)	168	1.1	0.65	80	0.65	0.81
Sep. (18 months)	290	1.37	0.49	158	1.31	0.87
The third year Mar. (25 months)	330	2.48	0.75	245	1.91	0.78

Table 2. The water content and the freezing point depression of the blood of the chum salmon reared in saltwater and freshwater ponds.

Age	Salt Water				Fresh Water			
	Fish	Water (%) content	Fish	$\Delta$ ( $^{\circ}\text{C}$ )	Fish	Water (%) content	Fish	$\Delta$ ( $^{\circ}\text{C}$ )
The first year Sept. (6 months)	3	$87.9 \pm 2.4$	3	$0.83 \pm 0.10$	3	$84.9 \pm 0.9$		
The second year Mar. (12 months)					4	$83.4 \pm 0.9$	4	$0.47 \pm 0.06$
Sep. (18 months)	12	$77.8 \pm 4.3$	15	$0.68 \pm 0.14$	11	$86.9 \pm 4.3$	15	$0.71 \pm 0.19$
Nov. (21 months)					10	$83.3 \pm 3.9$	7	$0.47 \pm 0.01$
The third year Mar. (25 months)	14	$76.5 \pm 3.9$	8	$0.58 \pm 0.13$				
Sept. (31 months)	5	$81.3 \pm 5.2$	4	$0.73 \pm 0.26$	3	$94.7 \pm 0.9$	2	$0.46 \pm 0.16$

Table 3. Results of rearing of chum salmon during the first year (C. Iioka, 1970).

Conditions	Saltwater pond	Saltwater pond	Saltwater pond	Saltwater pond
Period of rearing	6/18-11/20, 1970	6/18-11/20, 1970	6/18-11/20, 1970	6/18-11/20, 1970
Water temperature (°C)	15.0-21.5	15.0-21.5	15.0-18.5	11.5-17.5
Initial number	143	165	180	10,400
Initial average weight (g)	5.44	4.79	4.80	6.70
Final average weight (g)	40.0	38.9	46.9	82.9
Mortality (%)	71.4	49.8	15.5	87.1

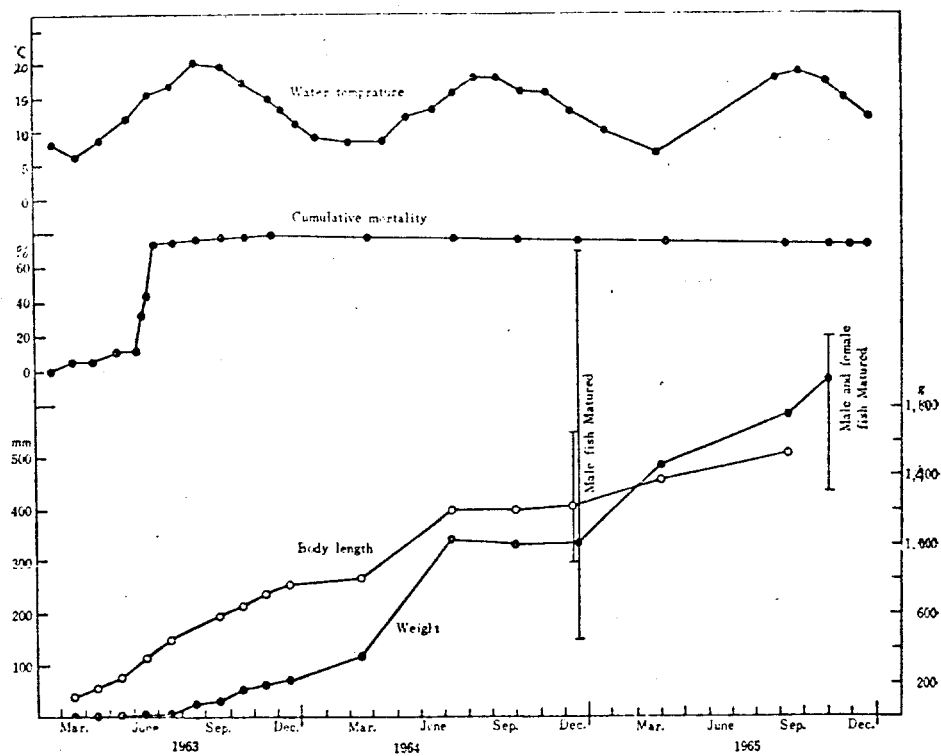


Fig. 1. Growth of chum salmon in the saltwater pond.

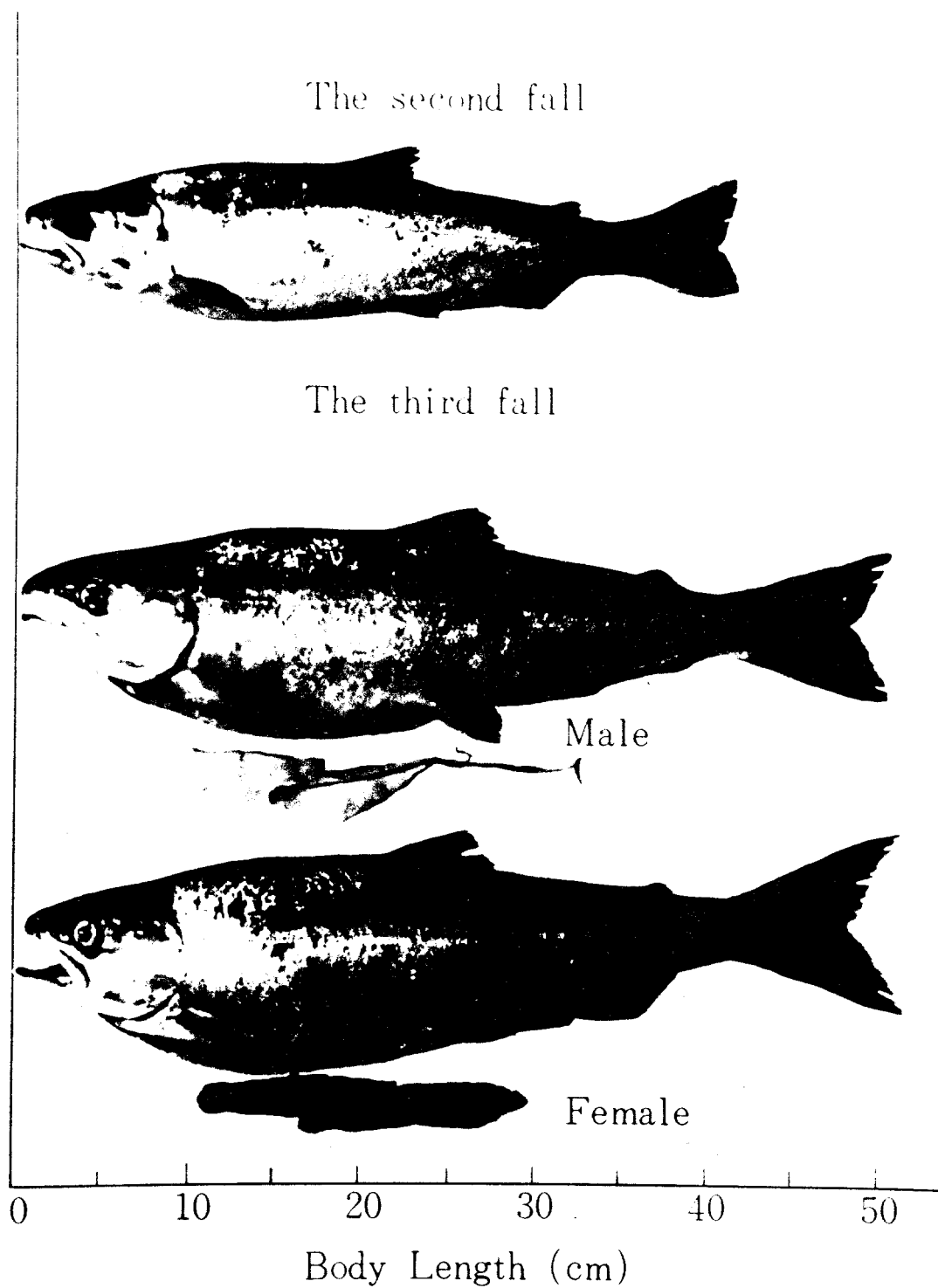


Fig. 2. Chum salmon reared in the saltwater pond.

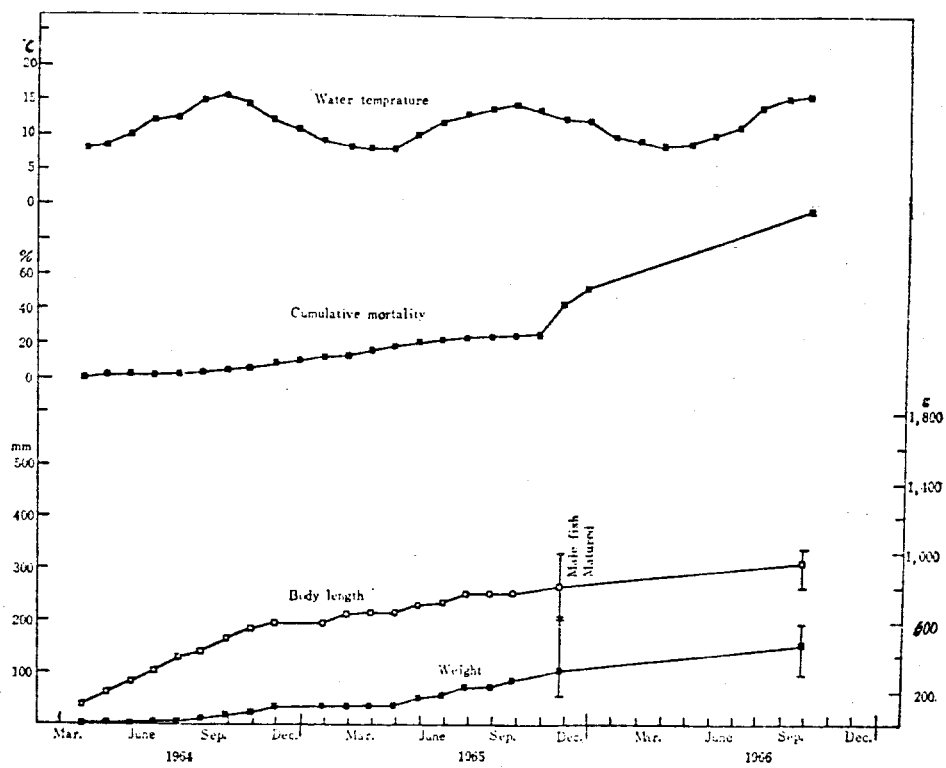


Fig. 3. Growth of chum salmon in the freshwater pond.

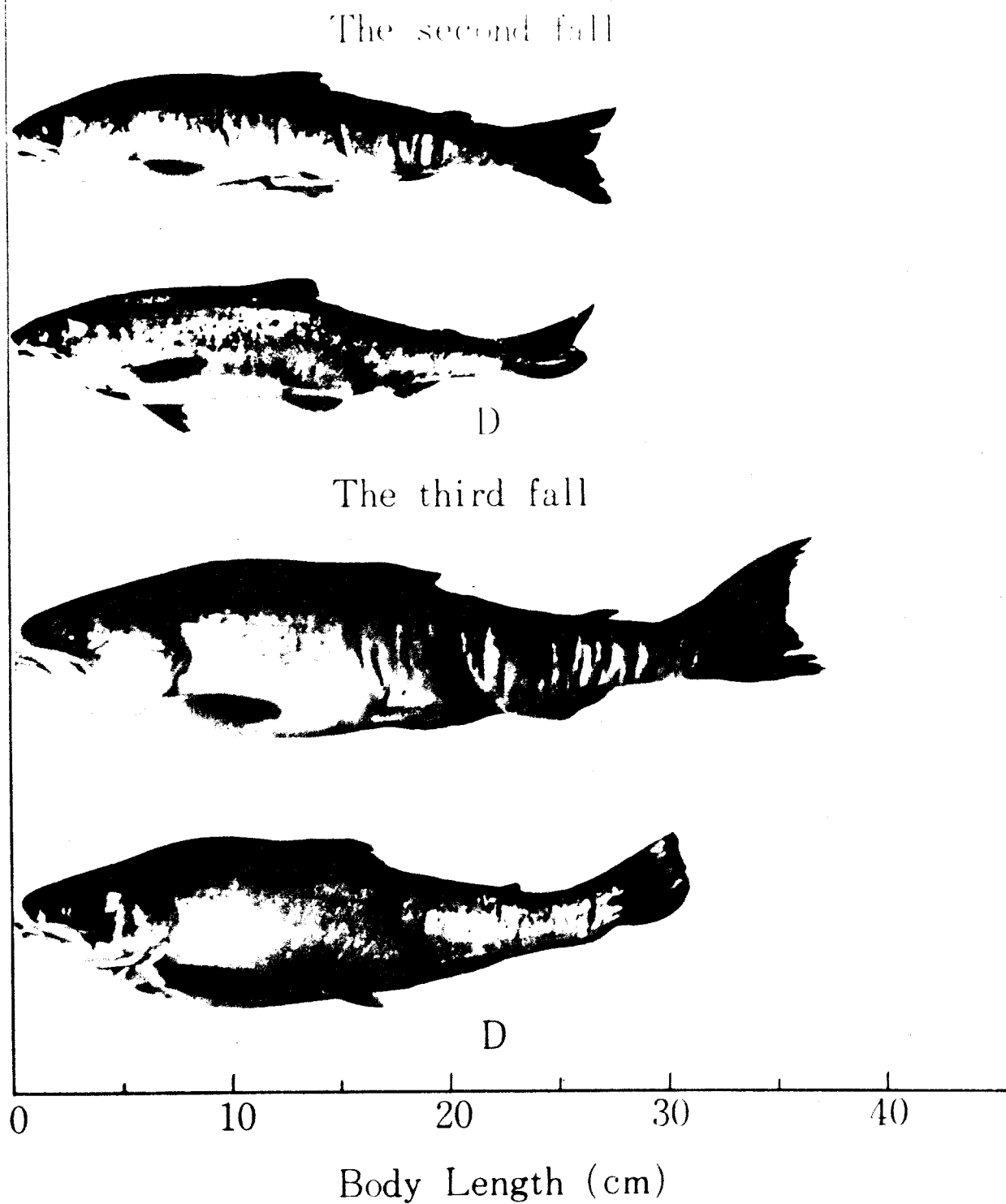


Fig. 4. Chum salmon reared in the freshwater pond. D indicates "dropsy like disease".

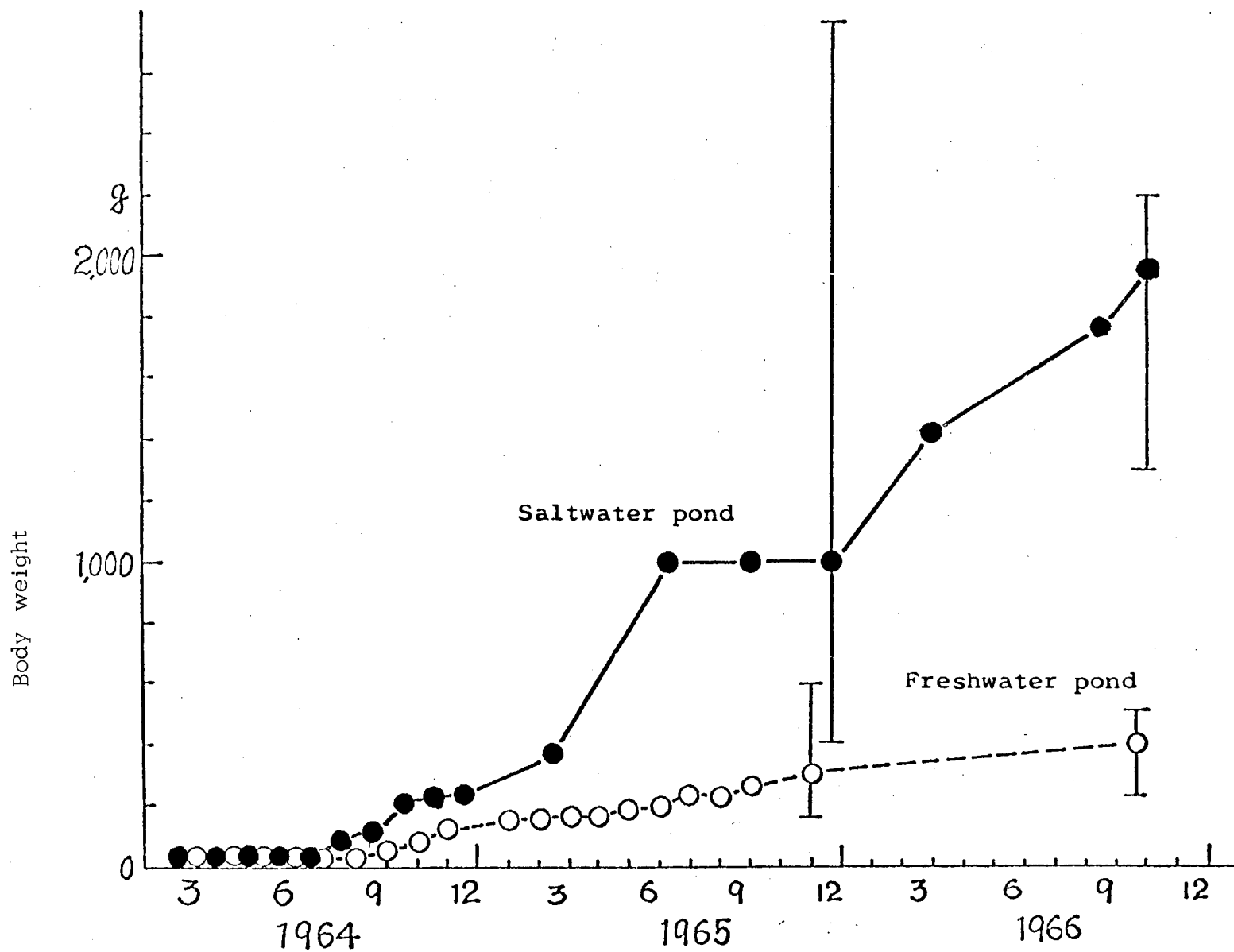


Fig. 5. Comparison of growth of chum salmon between the fish in saltwater and freshwater ponds.

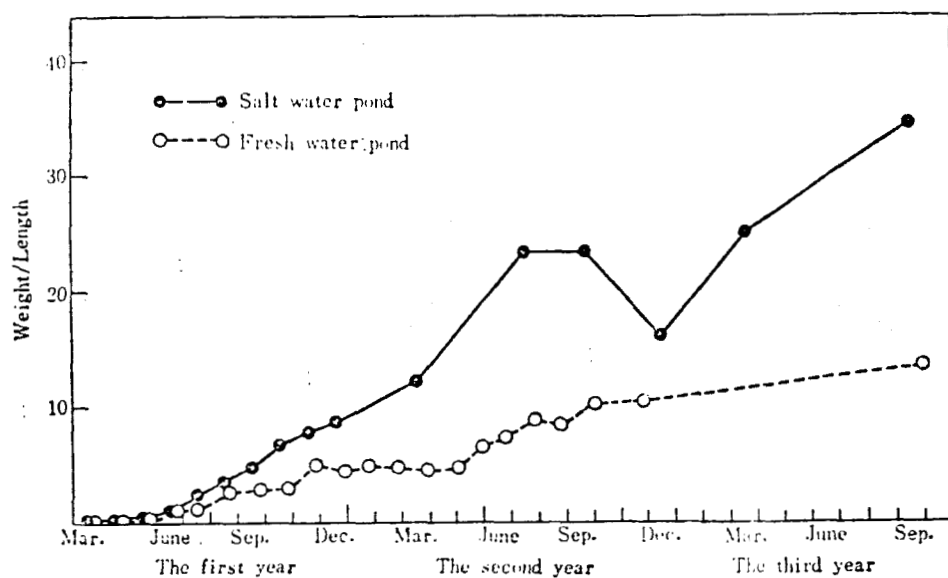


Fig. 6. The ratio of weight in gram to length in centimeter in chum salmon reared in the saltwater and freshwater ponds.

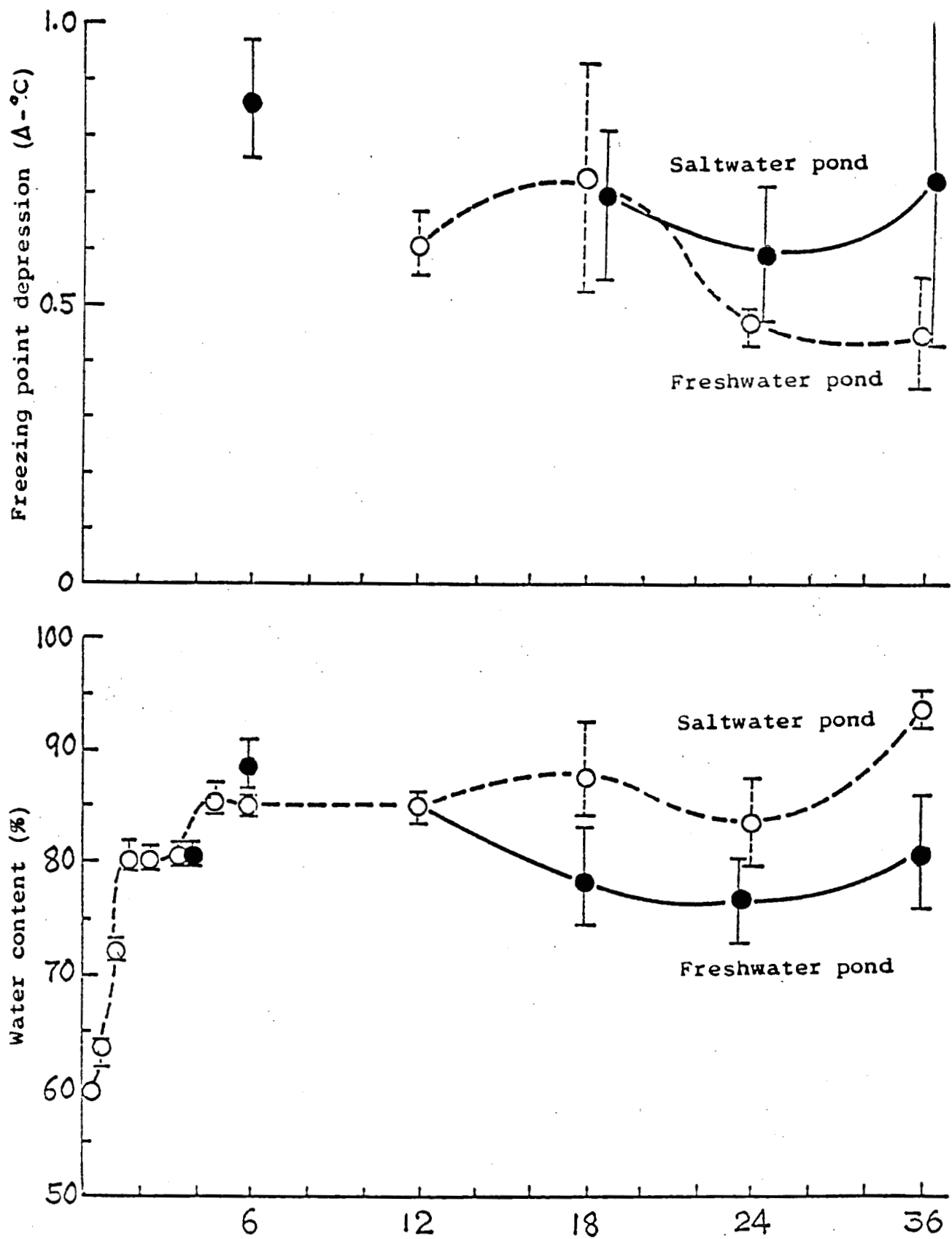


Fig. 7. The water content and the freezing point depression of the blood of the chum salmon reared in saltwater and freshwater ponds.

PANEL IV.

MULTIPLE USE OF WATERSHEDS

PANEL LEADER: Thomas D. Bird  
CFS, Vancouver, Canada

## THE SHORT TERM PHYSICAL EFFECTS OF STREAM CHANNELIZATION AT BIG BEEF CREEK

C. J. Cedarholm, Fisheries Research Institute, University of Washington

The economy of the Northwest is highly dependent on maintaining a natural and productive fisheries habitat. Anadromous and resident salmon and trout are found in the majority of the rivers and streams of this region. As rural populations continue to grow, many natural stream systems are becoming surrounded by housing developments. Although man must have room to expand, it is a shame that due to a lack of environmental planning and legislation our wild streams are becoming exception rather than the rule.

Encroachment on wild stream systems by land developers has not really become a problem in Alaska at this time, but it is becoming an ever present problem in British Columbia and the northwest United States. One has only to look at cities like Vancouver, B.C., Seattle and Portland, where most of the streams have been culverted, impounded, or channelized in one form or another. On the Kitsap Peninsula in Puget Sound (a relatively undeveloped area), almost every major stream system has either an artificial lake or a housing development now or proposed for the near future (Garling, 1962).

When a development is planned on a stream, one of the first orders of business is stream alteration to facilitate subdivision of the valuable stream-side property and to reduce the frequency of flooding. One technique used in the control of streams is channelization. Stream channelization has been defined by Emerson (1971) as: "...straightening of a stream or the dredging of a new channel to which the stream is diverted. The purpose is to minimize local flooding by shortening the distance traveled and thereby moving the flood waters downstream more rapidly."

What are the physical implications of channelizing a Northwest stream? Little is really known, although studies in the eastern United States have shown that physical degradation is the dominant result.

Hewlett and Nutter (1969) stated: "...channel improvement by straightening, dredging, or snag removal aims at lowering local flood peaks by increasing the capacity of the channel and the average velocity of the water. Temporarily effective in reducing flooding, channel work requires frequent re-dredging and causes much sediment movement."

I was able to study the short term physical and biological effects of a stream improvement project on a small Puget Sound salmonid stream. I will

discuss some of the physical effects that I observed at Big Beef Creek, Kitsap County, Washington. The objectives leading my discussion are as follows:

1. Present the changes in morphometric characteristics of the channelized area compared to the pre-treatment levels.
2. Present the degree of sediment (sand and gravel size) deposition in the lower .6 kilometer of the stream, and show how much sediment deposited in the channelized area came from the man-made channel and how much from upstream.
3. Show the degree of scour and fill of chum salmon redd sites within the channelized area, and estimate how many redds were lost (0% survival).
4. Recommend suggestions for improving stream alteration techniques as used at Big Beef Creek.

Big Beef Creek drains part of the west side of the Kitsap Peninsula in Kitsap County, Washington. The drainage basin has an area of 38 square kilometers and empties into Hood Canal near the town of Seabeck. Stream flows range between 3 c.f.c. and 1,000 c.f.c. with the storm flows occurring between November and April. Big Beef Creek supports runs of coho and chum salmon, steelhead and cutthroat trout, as well as other fishes of minor importance.

During the summer of 1969, the lower .6 kilometer of Big Beef Creek was channelized using standard stream improvement techniques. The major alterations included stream clearance, deepening, and rerouting. High dikes were bulldozed along the embankments to restrict the high flows to a narrow channel. The finished channel had the appearance of flume-like structure with no physical evidence of protection for the gravel dikes. There was a minimum of streamside cover (i.e., overhanging banks, shading vegetation, etc.) remaining for rearing salmonids or for spawner hiding places. During the two study years following stream channelization, erosion of the dikes and streambed degradation occurred. The stream habitat appeared to be quite unstable for both spawners and rearing juveniles in the channelized area.

## METHODS

Morphometric characteristics (i.e., pool numbers, pool area, etc.) of the channelized area before and after habitat alteration were established by field measurements and the use of aerial photographs. Streambed sediment

movement was estimated by using cross-sectional and topographic surveys of the channelized area before and after stormflows, and by the use of erosion index monitors in some cases. An unchannelized control was established .4 kilometers upstream.

## RESULTS

1. Over a 2-year period following channelization, the number of pools had reached 56% of the pretreatment level; the amount of pool surface area was 83% of the pretreatment level; the amount of streambank cover was 69% of the pretreatment level, and the average streambed slope was 118% greater than the pretreatment slope.
2. Following stream channelization, 59% (3,300 cubic meters) of the streambed sediment deposited within the channelized area came from widespread dike erosion and streambed degradation within the channelized area. The remainder of this sediment came from upstream sources.
3. Due to scour, fill, and being left high and dry, 52% of the chum salmon redd sites spawned within the channelized area were lost.

## RECOMMENDATIONS

### General

The existing natural conditions of a streambed (i.e., meander pattern, cross-sectional contour, gravel bar occurrence, slope, etc.) usually reflect the most efficient means by which the stream handles the sediment contributions from its drainage basin. Therefore, channelization of a naturally occurring streambed should be a last resort. Most streambed alterations imposed by man introduce new stresses to which the stream will react, and most likely in an undesirable way.

## CARNATION CREEK WATERSHED STUDY

David W. Narver, Fisheries Research Board of Canada

### Background

In British Columbia there is little scientific information about the impact of current logging and silvicultural practices on the productive capacity of salmon and trout streams or on water yield and water quality. At present fisheries and forestry managers, in designing protective clauses in cutting plans or timber licenses, must extrapolate from research results obtained in Oregon or Alaska to British Columbia situation with differences in climate, geology and vegetation. This has proven unsatisfactory to the resource managers.

In British Columbia a large portion of coho, pink and chum salmon and steelhead and cutthroat production is from small streams. Such streams, without lakes in the watershed to provide some flow control, are common in the high rainfall area along the British Columbia coast. These small streams are probably more susceptible to damage by the normal logging practices of clear cutting and frequently slash burning to the stream margin than are larger streams and rivers. Large scale silvicultural operations are becoming more common after logging such as burning, herbicide treatments, scarification, planting and fertilization and may have important effects on stream systems. The hydrological effects of logging and silvicultural practices must be known not only because fish production depends on water but also because of society's dependence. Finally there is an almost complete lack of understanding on how an unlogged coastal stream-mature rainforest-ecosystem works.

### Experimental Approach

Stream-watershed ecosystems are extremely complex. While short-term studies and studies of one to several variables are necessary and will provide some information on the possible effects of logging and silvicultural practices, most knowledge will be gained from fairly long-term ecosystem studies because it is impossible to separate the forest, fish and water resources of the watershed. Thus a long-term watershed study bringing together the expertise of a wide range of disciplines seems imperative.

Our study focuses on the capacity of the stream to produce salmonid fishes through an ecosystem approach which relates the activities of the

forest industry to the basic cycles (i.e., nutrients, hydrologic and energy) affecting the aquatic system. Such a study must start a number of years before commencement of logging activities in the watershed to establish baselines and must last well into reforestation.

It is also necessary to make certain physical and biological measurements of a large number of streams in various stages of reforestation to provide a basis for extrapolation from the single watershed study. Such surveys are being conducted as an adjunct to the Carnation Creek study.

### Study Area

Carnation Creek is a small coho and chum salmon, steelhead and resident cutthroat trout stream entering Barclay Sound near Alberni Inlet on the west side of Vancouver Island. The watershed is about 4 square miles containing no lakes and is entirely unlogged. It is in a high rainfall area (130-200 in.) with runoff patterns and floral associations that are probably fairly typical for western Vancouver Island and the coastal mainland of British Columbia.

### Design of Study

The Carnation Creek watershed is within a Tree Farm License held by MacMillan Bloedel. Logging was originally scheduled to begin in late fall of 1970, but the company has agreed to stay out of the watershed until beginning road construction in late summer of 1974 and logging in late fall and winter of 1975/76. Logging will be conducted for five winters until the lowest two-thirds of the watershed is logged (about 1,100 acres); the upper end of the watershed will be logged in the mid-1980's. The major goal in the design is that logging be as near as possible to normal winter operations. (Because it is in a low snowfall area, the Carnation Creek watershed is reserved for winter logging). Prelogging stream biology studies began in 1970 and stream physical and chemical studies in 1971.

A 2.5 square mile watershed six miles northwest of Carnation Creek will be used as a hydrological and biological control. The watershed is entirely unlogged and has a coho and chum salmon stream.

### Research Objectives

The broad research objectives of the Carnation Creek watershed study are: 1) understand and quantify the effects of certain logging and silvicultural

practices on a high rainfall watershed ecosystem containing an overmature commercial forest and a salmon and trout nursery stream and 2) recommend forest management practices to optimize, separately or in concert, the production of watershed resources of timber, fish and water.

The objectives of the study fall into six major categories. Stream biology includes studies on population dynamics of sculpins and salmonids, invertebrate benthos, terrestrial fauna, organic detritus and primary production. Stream environment includes water chemistry, spawning gravel, suspended sediment, erosion, debris and streamside vegetation. Hydro-meteorological includes discharge and water balance. Forest biology includes floral mapping, litter, disease and pests. Forest environment includes geological mapping and soils mapping, moisture and temperature. Watershed modeling includes qualitative flow charts, process modeling and watershed simulation.

#### Interagency Participation

The main participants in this study are all within the Federal Department of the Environment including Pacific Biological Station (Nanaimo); Environmental Quality Group, Southern Operations (Vancouver); Pacific Forest Research Centre, Canadian Forestry Service (Victoria); Water Survey of Canada; and Atmospheric Environment Service Disciplines included are biology, forest ecology, forest hydrology, civil engineering, meteorology and computer simulation. Additional input is obtained from MacMillan Bloedel Ltd., B.C. Forest Service, and Faculty of Forestry (UBC).

## EFFECTS OF FOREST HARVESTING ON FISHERY -- ALL BAD?

Robert P. Willington, University of British Columbia

### ABSTRACT

The increasing concern by various resource managers regarding the effects of forest harvesting on the fishery resource has resulted in an emphasis of the detrimental aspects at the expense of any possible beneficial effects of forestry on the fishery and fishery habitat. It is not that many of the detrimental effects are to be disputed, but concentration of inquiry effort in one direction may create a situation whereby any beneficial effects are overlooked. It is possible that, depending on the characteristics of the watershed and type of imposed treatment, the effect of harvesting will benefit, harm or, due to a balancing of beneficial and harmful effects not influence the fishery. At a time of necessarily rapid decision making regarding large scale harvesting operations in fish supporting watersheds, resource personnel involved in the management of forests and fish cannot afford to operate with "tunnel vision".

This paper invalidates tunnel vision and factionism by exploring a few of the beneficial effects of forest harvesting on the fishery resource. These effects are in the areas of watershed stability, flow augmentation and stream temperature. An equitable balance between fishery and forestry may best be achieved by eliminating tunnel vision and managing the forested land of the north Pacific Coast region according to watershed principles of stream response to vegetal manipulation.

# USING RESOURCE INFORMATION IN DECISION MAKING ON SOUTHEAST ALASKA WATERSHEDS

Joseph Zylinski, U.S. Forest Service

## ABSTRACT

Maps and overlays are used by the Alaska Region to provide resource information, locate specific requirements and identify areas of potential conflict in land use planning activities. More detailed information is available from sources, such as: timber or soil-type maps, watershed survey information, and special wildlife and recreation data.

Much of this information is qualitative in character and without sufficiently developed theory to provide quantitative estimates relating to resource values. "Linear analysis" as a tool for management decision making is still in the future for this region. Forest managers today combine these information sources with public inputs to make plans and decisions. This process can be satisfactorily used at this time to set courses of action. More quantified information and more comprehensive analysis coupled with a computer capability will be essential for future planning processes.

THE SAFEGUARDING OF FUTURE OPTIONS - WITH PARTICULAR  
EMPHASIS ON THE PROSPECTS OF IRREVERSIBILITY IN  
ENVIRONMENTAL DECISION POLICY

Philip A. Meyer, Canada Fisheries Service

A. Benefit-Cost Analysis -- A Tool, Not a Panacea

Benefit-cost analysis is a management tool designed to provide guidance for decision makers faced with certain types of problems. The emphasis is on the words "certain types of problems". All too often it is used in blanket fashion to meet every type of problem, regardless of suitability. Hence, while it can often provide a very good answer in the area of artificial enhancement, it sometimes provides a very bad answer in environmental decision making, particularly where irreversibility is involved. By irreversibility I mean a change in the environment which, when completed, has little or no likelihood of being reversed.

B. Benefit-Cost Analysis -- The Piecemeal Approach

All too often, for reasons of thrift, expediency, or even ignorance, a workable "project" approach in benefit-cost analysis is transferred 'in toto' to consideration of a large systems question. Here the approach becomes partial and inadequate. One specific benefit (say fish) is compared against another specific benefit (say power), and adversary positions are struck. The question of whether the proposed system is itself efficient or whether, in fact, there is a better system is seldom raised. This partial approach encourages inefficient "either-or" solutions. Further, by focusing on a single incursive development, it forces environmentalists into the psychologically disadvantageous position of representing environmental values as "costs" in the analysis, a gross inversion of reality. This approach, all too prevalent today (witness Moran Dam) does justice neither to the benefit-cost method nor to the public interest.

C. Inadequacies of the Benefit-Cost Method -- Irreversibility

While proper and comprehensive application of the benefit-cost methodology would greatly benefit decision makers, there remains a real question about its adequacy in the environmental field. Characteristically, the benefit-cost approach assumes constant knowledge, or a constant

advance in knowledge/technology. Uncertainty about the future is aggregated with certain other economic variables in determination of interest rate. If a wrong decision is rendered, some temporary loss may ensue, but eventually corrections will be made and society will return to the right track. This approach does not cause any great soul searching as long as corrections can be made. The problem arises because in the environmental area, corrections can very often not be made. Once a decision is rendered and implemented, it often becomes, for all intents and purposes, irreversible. And if we are honest, we must admit that our knowledge of the future, particularly of future preferences in the area of industrial-environmental tradeoffs, is very slight. To be totally rigorous we should apply to the net benefits associated with each system alternative in the benefit-cost calculation a probability factor representing the degree of certitude regarding the future that we can associate with our calculations. But, as is obvious, this certitude about the future is so slight as to render those calculations meaningless. Consequently, we may conclude that benefit-cost analysis, properly applied, can be a reasonably good tool for short term (i.e., reversible) decision making, but that when a one time irreversible decision is being considered, it becomes totally inadequate and, in fact, dangerous. It can then become, to use the phrase coined by a colleague, an option-limiting methodology.

D. Environmental Decision Making -- An Option Maximizing Approach

For any given level of uncertainty concerning future tastes, technologies, etc., the probability of making a wrong choice, as noted, is high. Moreover, the probability of "sticking" future generation with that choice varies directly with the irreversibility of the decision; to treat this fact cavalierly is, in the words of Roderick Haig-Brown, "criminal". It thus follows that avoidance of irreversibility must be the cornerstone of decision making in the environmental field. I would describe this approach as the option maximizing methodology. Undoubtedly, avoidance will not be total, nor perhaps should it. However, environmental considerations have too long been treated as constraints to already formulated "development" proposals. Under an option maximizing approach, option maximization would be treated as an objective, side by side with monetary goals. Nor is it a crude concept. Probability analysis can handle such an approach with some refinement and provide quantifiable answers.

E. Option Maximizing - Implication for the Fishery

This approach indicates that as long as water users are not mutually exclusive the only absolute limiting factor for any one user is the aggregated "failsafe" level required to ensure each user continued existence over the long term. Above that level, benefit-cost analysis, or some other allocative system could be used to assign "excess" water. We are then saying that from an environmental viewpoint, we must be prepared to give a little and lose a few fish (or in the extreme, all FISH) in a low water year to preserve the continued vitality of other users, but that, in turn, we should NOT be requested to endanger the long term viability of the fish runs.

Such an approach places on the incursive user (one whose use precludes use by one or more traditional users) the onus of showing (a) that his needs cannot be met by alternative and less damaging means, and (b) that failing a satisfactory alternative in (a), his needs possess sufficient validity and importance to justify embarkation on an irreversible course of action. This is a fry cry from the perverse position we often find ourselves in attempting to justify why the environment should not be irreversibly damaged.

In closing, I would agree that in many quiet ways, just such an approach is being followed. Firms, for instance, are beginning to consult us in pre-planning, rather than post-planning stages of projects. However, to my knowledge, no attempt has been made to indicate the essential differences between benefit-cost and option maximization approaches. These differences are in emphasis rather than method, for cost-benefit analysis could theoretically encompass irreversibility. However, with a high-degree of uncertainty about the future, its answers should not be trusted when irreversible decisions are being contemplated. Option maximization has been tentatively advanced in Committee meetings on the Okanagan Basin and has been greeted favorably by some members. I feel it could also be advanced with considerable merit in the Moran controversy, as well as some of the large estuary problems we face.

## THE NECESSITY FOR A SYSTEM APPROACH IN INTEGRATED WATERSHED MANAGEMENT

T.W. Chamberlin, Canada Fisheries Service

Integrated watershed management requires decisions to be made which integrate the use of diverse resources. These decisions are made by specialists with different values, goals, and means, and for whom different environmental parameters are important, and unimportant.

Current research and management objectives are problem oriented; missions are by objective. While maximizing current results, such as approach often fragments problems which have a larger context. It is argued that we are in an era when any problem must be studied in an ecosystematic context, and in which what we do not know must play as important a role as what we do. Such a system approach emphasizes the definition of components, the interfacing of components output and input parameters, and the dynamic interaction of system components.

The effect of a system approach on a resource specialist is to ensure that decisions are not made in isolation, that the possibility of being wrong is considered, and that short term results are considered in the light of possible changes in future conditions.

## SUMMATION AND CRITIQUE

W.L. Sheridan and D.M. Bishop, U. S. Forest Service

Northeast Pacific Pink Salmon Workshops have been held every two years since 1962. The basic objective of the workshop is to improve research and management of pink salmon in the northeast Pacific. The workshop provides a channel of communications whereby fishery biologists can discuss problems of mutual interest and keep abreast of recent developments in the field. The Interagency Council is to be provided with information on forecasts, research and other problems.

Overall, the meeting at Sitka in 1972 was excellent and in my opinion fulfilled workshop objectives. There are many good happenings which I think attendees were well aware of. I would, however, like to emphasize some of the negatives, as well as the positive, aspects, as follows:

1. There were about 85 people attending. The previous high in 1968 was 80 in Ketchikan. The present size precludes workshop procedures. Therefore, "Workshop" should be changed to "Conference" because it is misleading, or the format should be changed so that a workshop atmosphere is restored.
2. I do not believe Sitka is an appropriate location for the meeting. All people attending the meeting should be housed in one place. The Centennial Building in Sitka is very nice, but the room was too large for easy exchange between participants.
3. There was a tremendous range in quality of presentation of papers presented, from very poor to excellent. I suggest that the present Steering Committee read carefully Scientific Communication via Meetings by D.W. Chapman, in Trans. Am. Fish. Soc., April, 1971, pages 400-402 before they plan for the next meeting. Chapman recommends that the panel chairman obtain topics of papers to be presented long before the meeting. He can then review and approve visual aids, and screen the papers for format, quality, and pertinence to the overall panel theme. Chapman also discusses several other points that are germane to organization of the Pink Salmon Workshop.
4. It happens that sometimes a group has a meritorious idea that they successfully execute. This was the case with the Pink Salmon Workshop in 1962. (At that time, all those attending were seated around a standard conference table). Like Topsy's little sister Gretchen, the workshop grew and grew and changed and changed. Is it now like some of the timber the Canadians talked about in B.C., overmature and decadent? I recommend that the present

Steering Committee take a good look at where we are and where we want to go. Revolutionary ideas for reorganization may be needed.

5. Some of the suggestions I gleaned from the audience were: (a) exert stronger control by panel chairmen over timing and punctuality, (b) have shorter papers with more and shorter breaks and, (c) have more speakers and shorter papers, presenting results without dragged out presentation of methods. The size of the room and seating arrangement was criticized as contributing to an atmosphere of stiffness.

6. An area of varying opinions was the discussion of even and odd-year runs. It seems that after all this time there is a distinct lack of knowledge here. This is suggested as a topic for a future meeting.

7. Time lag to publication of results of research is a problem for managers. They needed this information yesterday. Periodic progress reports, properly distributed, may be the answer. Fisheries Research Board of Canada used to have these, but discontinued them. Researchers shouldn't be doing research as an ego trip, but for application of the results. There isn't much time and things are happening fast. Decisions on land management and fishery management must be made.

Dan Bishop's remarks are given below.

The several workshops I have either attended or participated in have been a continuous source of education to me, a non-biologist, forester-hydrologist. An important role and perhaps a larger potential of these sessions is to expose and stretch people like me to a more thorough understanding of the real complexities and interactions of salmon biology and management. A somewhat unreached potential of these sessions remains the inclusions of more contributions from physical disciplines. There is repetition and perhaps some redundancy in these sessions, and yet I feel there is an essence (or perhaps essences) developing.

Environmental concerns have been referred to in this as well as in previous sessions. Yet this seems to be the first session where some actual discussion -- either on a project level, such as Atomic Powerplants in Puget Sound, or on a more abstract level, dealing with resources and social model building -- actually got underway. We need to hear more from both of these perspectives, and can expect rapid refinement of technique and philosophy, a fleshing out of both local (specific) and general (abstract) approaches. I would like to suggest two subject areas that may benefit by a comprehensive problem-wide review.

During these workshops we have heard a great deal in depth about gravel composition, about ping-pong balls, about gravel shift. These discussions, the result of a tremendous amount of hard and tenacious finger-nail-grinding physical work, and stubborn, pencil and computer-pushing sieges, have resulted in numerous solos on the part of men of several Canadian and American agencies, and yet these efforts remain considerably isolated.

Another example: At this workshop, I listened to a most comprehensive rundown of ways to artificially produce salmon. There was a considerable point-counterpoint-undertone of competition -- a very healthy sign. Techniques were described in varying detail and style, but the array of techniques, and the varied physical and biological factors remain difficult to view in a logical fashion.

I have chosen these two subjects as examples of an existing need to gather extensive fields of information into a central theme. It is timely to do this not only because much information is hanging around loose in the related agencies, but also because it is clear, partly through these workshops, there is a lot of young, new and enthusiastic talent trained and capable of rigorous, innovative analysis.

The streambed gravel-related picture needs to be pulled together coastwide. I suspect we can establish working field principles much more accurately by a pooled effort. A common base for listing existing gravel information, coupled with gathering and listing of physical hydraulic variables for each sample reach might be a significant beginning. This should then warrant an analysis attempting to develop empirical relationships between physiography, soils-geology, hydro-climatic conditions, specific hydraulic parameters of the sample reach versus streambed characteristics. The results of this analysis would be of potential use to land-stream managers and researchers.

In the second instance -- artificial salmon production methods -- an effort is needed to pull together the pertinent information describing alternative or complementary improvement systems. Capital costs need to be put on a common base. Maintenance costs likewise; kinds of benefits and losses must be realistically listed, a comparative evaluation of public preference or potential involvement is needed; physical requirements or limitations -- water, sediment, gravel volume, logistics, water/air temperature -- need to be comparatively summarized.

An assembly of this kind of information is going to be very useful or essential for selection to be made.

## ADDENDUM

### WORLD PINK SALMON CATCH STATISTICS

1952 - 1970

Michael B. Dell and Allan C. Hart, Fisheries Research Institute

The attached tables and figures summarize the catches of pink salmon in all major production areas of Asia and North America together with the high seas catches by Japan for the years 1952-1970. North American catches for 1971 (preliminary) are also included. The area divisions are defined in Table 1 and illustrated in Figure 1.

The data are an updating of the world pink salmon statistics as presented in Panel I of the 1970 workshop. They are included in the present report in order to provide workshop participants with current and historic statistics under one cover, and to keep ourselves informed of the status and trends in the pink salmon resource both as a whole and by major production area.

Table 1. District definitions for pink salmon catch statistics\*

Area No.	Description
1	Amur River and Primore coast of U.S.S.R.
2	Sakhalin and Kurile Island coastal
3	Okhotsk Sea coastal
4	West Kamchatka coastal
5	East Kamchatka coastal
6	Japan Sea - offshore
7	Okhotsk Sea - offshore
8	Japanese land-based fishery (N. Pacific - offshore)
9	Japanese mothership fishery (Pacific)
10	Japanese mothership fishery (Bering Sea)
11	Northwestern Alaska
12	Aleutian Islands and south side Alaska Peninsula
13	Kodiak Island area
14	Cook Inlet and Resurrection Bay
15	Prince William Sound and Copper, Bering, and Yakutat rivers
16	Southeastern Alaska (north part - Icy Straits - western - eastern districts)
17	Southeastern Alaska (south part - Sumner Strait, Stikine, South Prince of Wales, Clarence Strait, Southern - Dixon Entrance, Hecate Strait)
18	Northern British Columbia
19	Southern British Columbia
20	Fraser River (I.P.S.F.C. treaty areas)
21	Washington State
22	Oregon State

\* See Figure 1. Districts derived from I.N.P.F.C. Statistical Yearbooks with some grouping of minor areas.

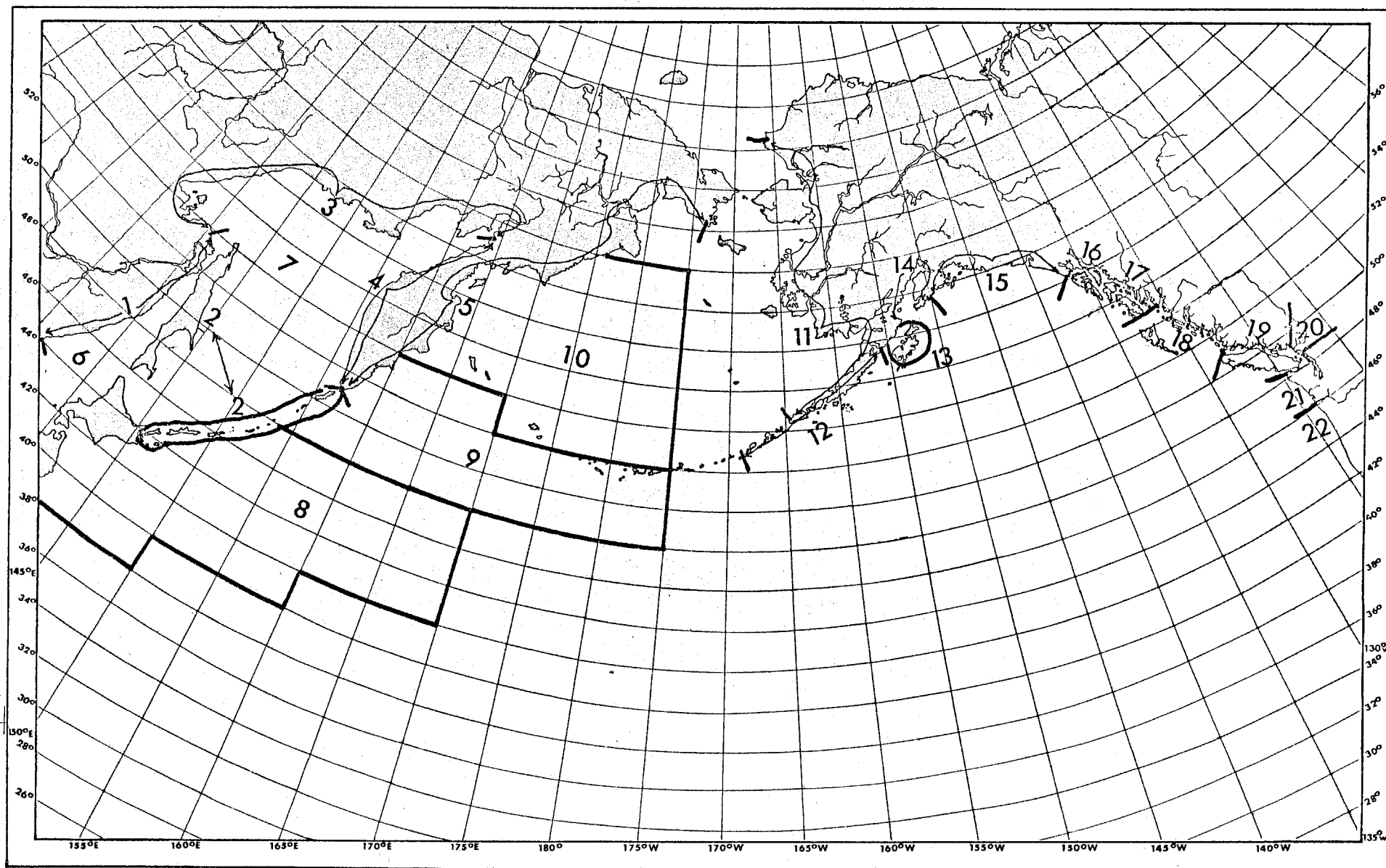


Fig. 1. GEOGRAPHIC AREAS FOR PINK SALMON CATCH STATISTICS - (SOURCE TABLE 1).

Table 2. Pink salmon catches - U.S.S.R., 1952-1970 in millions of fish.

Source - unpublished INPFC documents and correspondence.

Year	Amur River & Primore Coast 1	Sakhalin & Kurile Is. 2	Okhotsk Sea Coast 3	West Kamchatka 4	East Kamchatka 5	Total
1952	1.5	6.0	0.7	27.9	5.0	41.1
1953	0.9	4.0	13.9	71.8	10.7	101.3
1954	1.4	11.9	0.4	15.4	3.8	32.9
1955	0.4	10.5	13.6	29.4	8.9	62.8
1956	5.3	25.4	0.8	19.5	0.3	51.3
1957	1.1	8.7	12.3	37.8	15.9	75.8
1958	8.8	13.7	2.7	0.9	1.2	27.3
1959	2.1	10.5	1.7	6.3	12.8	33.4
1960	3.3	3.3	2.7	1.4	3.3	14.0
1961	0.6	5.1	3.0	3.2	9.7	21.6
1962	1.2	1.2	2.5	1.9	4.0	10.8
1963	1.7	3.8	6.6	3.6	9.7	25.4
1964	1.3	1.8	1.7	0.3	5.5	10.6
1965	2.1	13.3	5.4	1.8	12.1	34.7
1966	2.5	6.6	0.1	--	4.8	14.0
1967	4.4	16.5	--	2.1	10.1	33.1
1968	1.3	7.0	--	--	1.8	10.1
1969	4.6	27.2	--	0.9	10.1	42.8
1970	0.4	6.4	0.1	--	4.2	11.1

Table 3. Pink salmon catches - Japan - 1952-1970 in millions of fish.

Source - INPFC Statistical Yearbooks

Year	Japan Sea	Land- based fishery (Pacific area)	Mothership fishery				Grand total
			Okhotsk Sea	North Pacific	Bering Sea	Total	
			7	9	10		
1952	0.6	18.6	-	0.7	-	0.7	19.9
1953	0.5	13.3	-	3.0	-	3.0	16.8
1954	1.3	12.9	-	4.7	-	4.7	18.9
1955	1.1	28.0	9.3	14.2	-	23.6	52.6
1956	2.0*	35.4*	5.4	11.8	-	17.2	54.6
1957	2.6*	45.4*	6.8	17.0	4.0	27.8	75.8
1958	3.0	51.8*	2.3	13.0	0.2	15.5	70.3
1959	10.9	49.0	-	9.3	9.5	18.8	78.7
1960	13.8	32.1	-	0.8	1.1	1.9	47.8
1961	6.5	49.4	-	2.8	0.4	3.2	59.1
1962	3.9	26.1	-	1.1	-	1.1	31.1
1963	7.4	44.2	-	5.0	1.7	6.7	58.3
1964	5.1	22.7	-	1.6	0.5	2.1	29.9
1965	8.3	39.4	-	1.9	2.5	4.4	52.1
1966	8.4	25.4	-	1.3	1.2	2.5	36.3
1967	12.8	34.0	-	4.4	3.4	7.8	54.6
1968	9.4	23.6	-	2.2	1.6	3.8	36.8
1969	13.7	37.5	-	2.9	4.1	7.0	65.2
1970	6.4	16.7	-	0.8	0.9	1.7	24.8

\* Japan sea and land-based catch distribution for 1956-1970 based on average of percent from 1953, 1954, 1955. (Land-based fishery = 94.6%, Japan Sea = 5.4%.)

Table 4. Pink salmon catches - North American coastal fisheries, 1952-1971, in millions of fish.

Source - Kasahara, 1963 (Tables 53, 62 &amp; 67, 1951-61)

INPFC Statistical Yearbooks, 1951-1970

ADF&amp;G &amp; CDF prelim. - 1971

Year	District numbers and descriptions (Figure 2 and Table 1)												Total
	11	12	13	14	15	16	17	18	19	20	21	22	
	N.W. Alaska	Aleutian Is. & S. Alaska Penin.	Kodiak Island	Cook Inlet & Res. Bay	Pr. Wm. Sd. Cop. & Ber. rivers Yakutat	N. part S.E. Alaska 1/	S. part S.E. Alaska	N. B.C.	S. B.C. 2/	Fraser River 3/	Wash. 4/	Ore.	
1952	0.1	1.0	4.6	2.3	2.2	3.4	6.3	8.3	2.9	-	-	-	31.1
1953	0.1	2.9	5.2	0.6	2.0	1.2	3.8	1.8	8.2	1.1	6.1	-	33.0
1954	0.1	2.2	8.4	2.5	-	2.4	6.5	4.9	0.6	-	-	-	27.6
1955	-	2.7	10.8	1.3	0.1	4.1	5.2	3.8	6.6	0.8	5.2	-	40.6
1956	0.1	2.3	3.3	1.8	4.5	3.5	10.0	6.2	1.1	-	-	-	32.8
1957	-	1.0	4.7	0.3	0.7	2.2	4.7	4.2	6.2	0.9	3.2	-	28.1
1958	1.2	2.1	4.0	2.6	6.4	3.3	6.5	5.5	1.4	-	-	-	33.0
1959	-	1.0	2.0	0.1	-	4.3	3.6	1.9	4.3	0.5	2.6	-	20.3
1960	0.3	2.1	6.7	2.0	1.9	1.4	1.5	3.7	0.4	-	-	-	20.0
1961	-	2.3	3.9	0.3	2.4	8.8	3.9	5.9	2.3	0.1	0.8	-	30.7
1962	1.0	5.5	14.1	5.0	6.8	0.5	11.0	22.6	0.9	-	-	-	67.4
1963	0.1	4.1	5.5	0.2	5.4	13.9	5.1	5.5	6.1	0.6	6.3	-	52.8
1964	1.6	4.6	12.0	4.3	4.2	7.3	11.3	8.7	0.9	-	-	-	54.9
1965	-	4.0	2.9	0.1	2.5	5.1	5.7	3.8	1.2	0.1	0.7	-	26.1
1966	2.5	1.0	10.8	2.6	2.7	4.8	15.6	13.7	3.6	-	-	-	57.3
1967	-	0.2	0.2	0.4	2.7	2.4	0.6	1.5	7.7	0.5	4.1	-	20.3
1968	2.1	3.5	8.8	2.9	2.5	9.8	15.1	15.7	3.9	-	-	-	64.3
1969	-	3.2	12.5	0.2	4.9	3.7	1.2	0.9	1.4	0.3	1.0	-	29.3
1970	0.5	3.7	12.0	1.4	2.8	5.2	5.4	10.9	2.8	-	-	-	44.7
1971	-	2.1	4.3	0.4	7.4	2.9	6.1	2.1	5.7	0.6	2.8	-	34.4
1972													

1/ Areas 109-115.

2/ Incl. some Fraser R. fish.

3/ Incl. only Canadian catch in District 1.

4/ Incl. Fraser R. fish in Wash. waters.

Table 5. World pink salmon catch statistics 1952-1970 (in millions of fish).

Source: Tables 2, 3, 4.

Year	Catch by area			Total
	Asian Coastal	High Seas	North Amer. Coastal	
1952	41.1	19.9	31.1	92.1
1953	101.3	16.8	33.0	151.1
1954	32.9	18.9	27.6	79.4
1955	62.8	52.6	40.6	156.0
1956	51.3	54.6	32.8	138.7
1957	75.8	75.8	28.1	179.7
1958	27.3	70.3	33.0	130.6
1959	33.4	78.7	20.3	132.4
1960	14.0	47.8	20.0	81.8
1961	21.6	59.1	30.7	111.4
1962	10.8	31.1	67.4	109.3
1963	25.4	58.3	52.8	136.5
1964	10.6	29.9	54.9	95.4
1965	34.7	52.1	26.1	112.9
1966	14.0	36.3	57.3	107.6
1967	33.1	54.6	20.3	108.0
1968	10.1	36.8	64.3	111.2
1969	42.8	65.2	29.3	137.3
1970	11.1	24.8	44.7	80.6
1971			34.4*	
1972				
19-year total	654.1	883.6	714.3**	2252.0
19-year average				
1952-70	34.4	46.5	37.6	118.5

\* Preliminary - see Table 4

\*\* 1971 not included

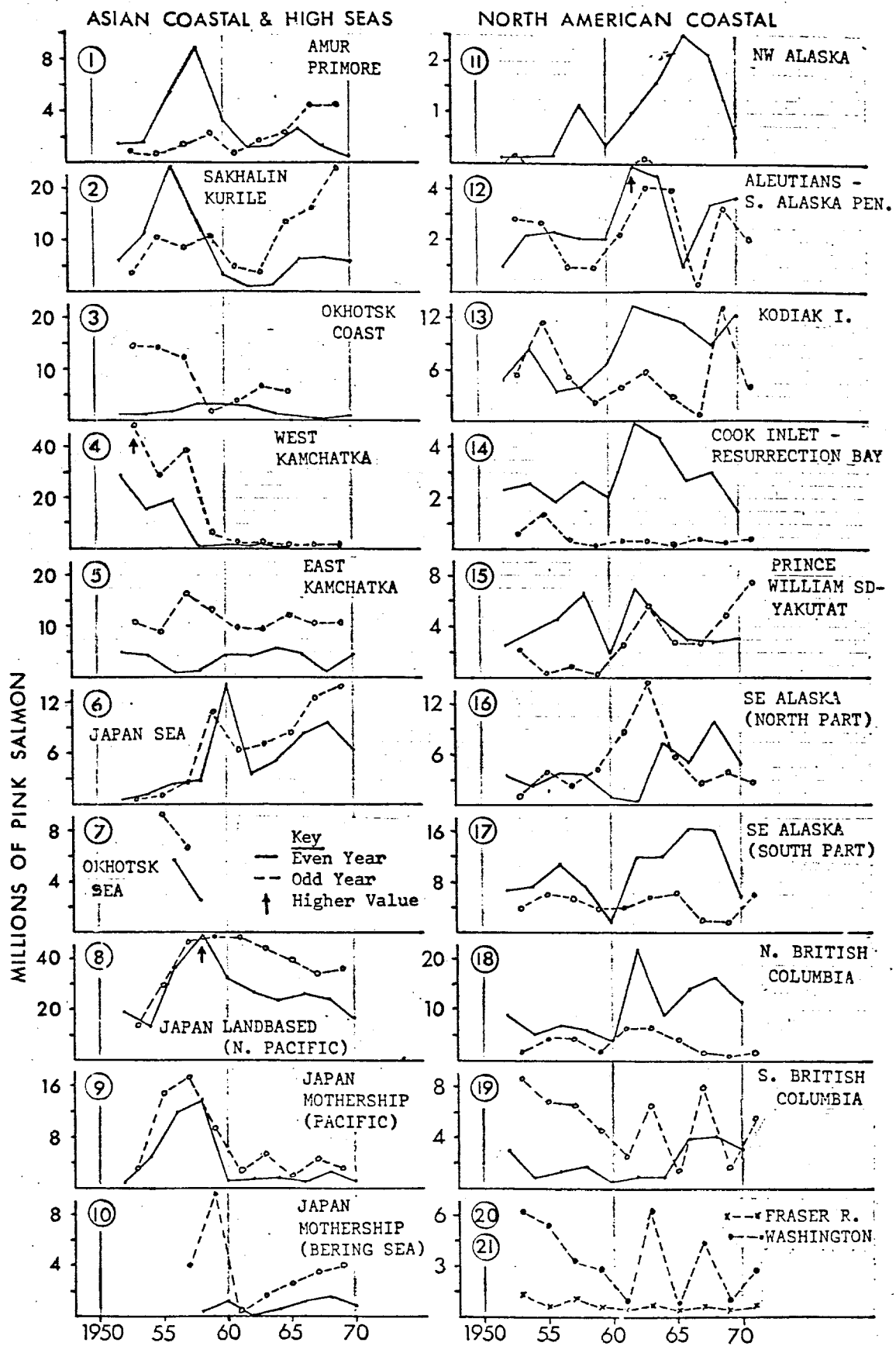


Figure 2. North Pacific pink salmon catch by district, 1952-1971.

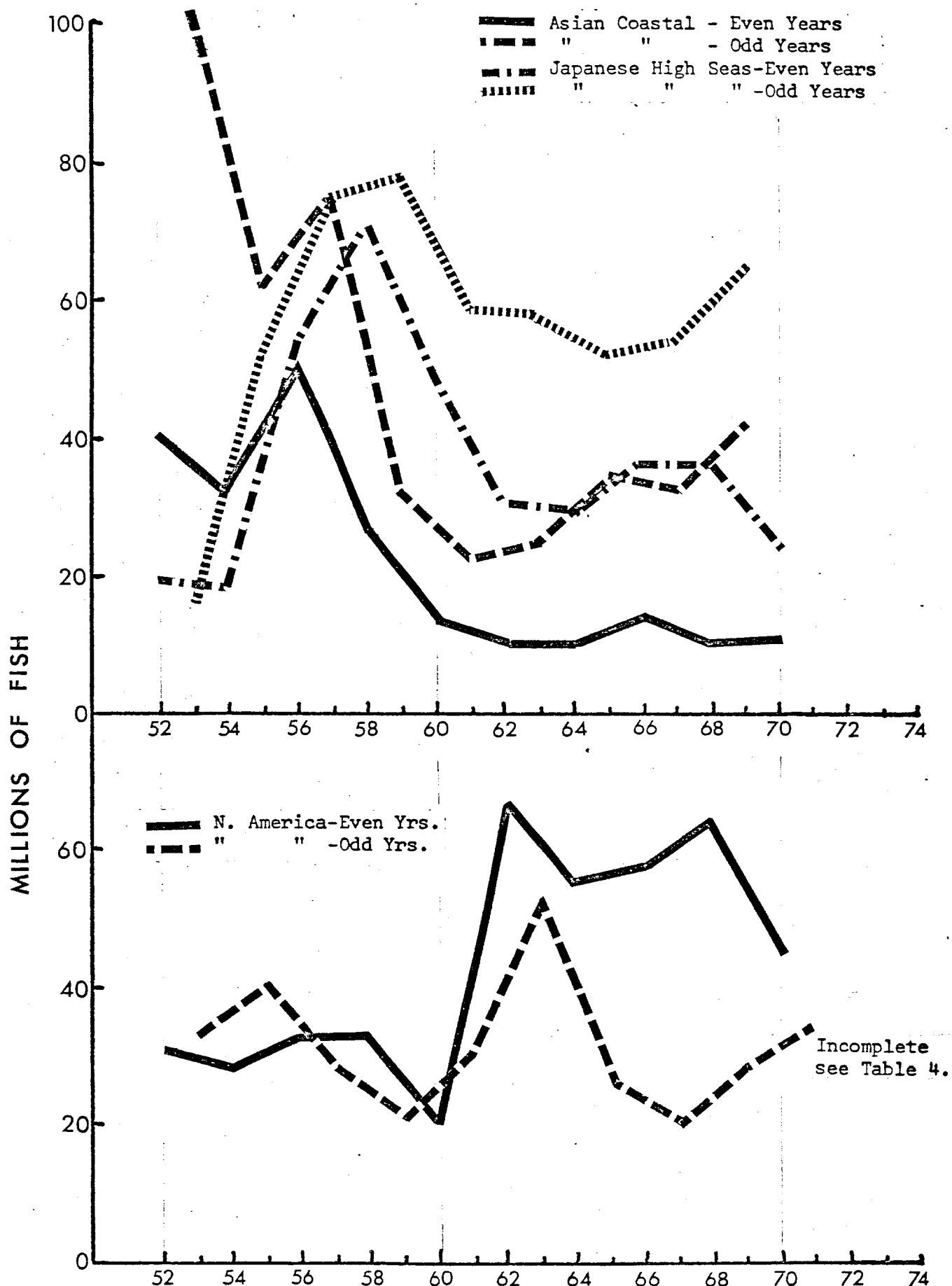


Figure 3. Pink salmon catches in major Asian, high seas, and North American fisheries, 1952-1970 (source - Table 5).

## APPENDIX I

### ROSTER OF 1974 STEERING COMMITTEE

\*Mr. Thomas D. Bird, Chairman  
Canada Department of the Environment  
Fisheries Service  
Vancouver 5, B.C., Canada

Mr. John H. Helle  
National Marine Fisheries Service  
P. O. Box 155  
Auke Bay, Alaska 99821

Mr. Roger Blackett  
Alaska Department of Fish and Game  
P. O. Box 686  
Kodiak, Alaska 99615

Mr. Bud Jewel  
Washington Department of Fisheries  
115 General Administration Building  
Olympia, Washington 98501

\*Mr. Alan B. Chapman  
International Pacific Salmon Fisheries  
Commission  
P. O. Box 30  
New Westminster, B.C., Canada

Dr. K. V. Koski  
Fisheries Research Institute  
University of Washington  
Seattle, Washington 98195

Mr. Thomas M. Collins  
U. S. Forest Service  
P. O. Box 1628  
Juneau, Alaska 99801

Dr. David W. Narver  
Fisheries Research Board of Canada  
Nanaimo, B.C., Canada

Mr. Fred Fraser  
Canada Department of the Environment  
Fisheries Service  
1155 Robson Street  
Vancouver 5, B.C., Canada

\*Holdover from 1972 Steering Committee

## APPENDIX II

### RESPONSE TO QUESTIONNAIRE

1. Should we continue pink salmon workshops?

Yes	32	No	0
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2. Is the biennial schedule suitable?

Yes	31	No	1
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3. Length of meeting

Satisfactory	28
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Recommended change:

Add one day	2
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Subtract 1/2 to one day	2
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4. Format of meeting

Satisfactory	19
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Recommended change	12 (See comments below)
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5. Preference for location in 1974 (frivolous responses excluded)?

Vancouver or Vancouver Island	6
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Victoria	4
----------	---

Anchorage	1
-----------	---

Nanaimo	1
---------	---

Prince Rupert of Ketchikan	1
----------------------------	---

6. Topics recommended for 1974.

Order of preference for topics listed on questionnaire	Points
Artificial propagation	77
Multiple use of watersheds	53
Habitat protection and improvement	30
Coordination and research	29
Factors influencing abundance in freshwater	29
Optimum escapement; spawner-recruit studies	28

## APPENDIX II (continued)

Research needs of management	28
Economics of the resource. Cost benefits	26
Pollution -- pesticides and oil	26
The future of pink salmon	24
Forecasting	22
Sampling programs and equipment	22
Factors influencing abundance in early marine life	17
High seas studies -- migration -- oceanography	17
Cyclic dominance of pink salmon	16
Regulations	15
System model as a management tool	11
Mortality factors -- predation, disease and parasites	9
Genetics	8
Racial studies	8
More fish -- why?	6
Steering Committee option	6
Review of statistics and trends	4
Technology -- processing -- marketing	4
Saltwater growth and survival	3

Points were given on the following basis:

1st order of preference	6 points
2nd " " "	5 points
3rd " " "	4 points
4th " " "	3 points
5th " " "	2 points
6th " " "	1 point

### 7. Other comments (for guiding future Steering Committees).

CHANGES:	Number of Comments
Include all salmon species	5
More interchange with the audience - less formal	5
Limit attendance -- too many this year	5
At least one workshop problem solving session	4
1st evening cocktail party -- get acquainted -welcome	2
Smaller room	1
Invite certain speakers to present critical reviews of certain topics	1

APPENDIX II (continued)

Hand out sheets from speakers	1
Distribute agenda before meeting	1
More formal professional meeting	1
Include speakers of renown but direct discussions toward people involved with fish resource	1
Neck-mounted microphone for speakers	1
Do not use opaque projector	1
Hold meetings in towns where entire delegation can be housed in one building	1

### APPENDIX III.

#### LIST OF REGISTRANTS

ADF&G: Alaska Department of Fish and Game

Andrews, Rupert, Subport Building, Juneau, Alaska, 99801  
Armstrong, Robert, 188 So. Franklin, Juneau, Alaska, 99801  
Barry, James, 2414 Tongass, Ketchikan, Alaska, 99901  
Beck, Robert, Subport Building, Juneau, Alaska, 99801  
Blackett, Roger, Box 686, Kodiak, Alaska, 99615  
Blankenbeckler, Dennis, ADF&G, Ketchikan, Alaska, 99901  
Brahry, Bradley, ADF&G, Wrangell, Alaska, 99929  
Burnett, Robert, Subport Building, Juneau, Alaska, 99801  
Cantillon, David, 188 So. Franklin, Juneau, Alaska, 99801  
Cesar, Kenneth, 188 So. Franklin, Juneau, Alaska, 99801  
Davenport, Glenn, ADF&G, Cold Bay, Alaska, 99571  
Davis, Alan, Box 499, Sitka, Alaska, 99835  
Davis, Allen, Box 234, Homer, Alaska, 99603  
Downey, Gerry, 2414 Tongass, Ketchikan, Alaska, 99901  
Durley, Kenneth, 188 So. Franklin, Juneau, Alaska, 99801  
Eaton, Martin, Box 686, Kodiak, Alaska, 99615  
Finger, Gary, Subport Building, Juneau, Alaska, 99801  
Flagg, Loren B., Box 234, Homer, Alaska, 99603  
Gwartney, Lou, Box 686, Kodiak, Alaska, 99615  
Heinkel, Harold Jr., 2414 Tongass, Ketchikan, Alaska, 99901  
Hurd, Charles, Box 862, Nome, Alaska, 99762  
Kingsbury, Alan, 188 So. Franklin, Juneau, Alaska, 99801  
Lechner, Jack, Box 686, Kodiak, Alaska, 99615  
Manthey, Ken R., Box 686, Kodiak, Alaska, 99615  
McHugh, Michael, 188 So. Franklin, Juneau, Alaska, 99801  
McRea, Alex, Subport Building, Juneau, Alaska, 99801  
Morgan, Charles J., ADF&G, Box 47, Glennallen, Alaska, 99588  
McMullen, John C., 188 So. Franklin, Juneau, Alaska, 99801  
Malloy, Larry, Box 686, Kodiak, Alaska, 99615  
Nelson, Michael, ADF&G, Box 199, Dillingham, Alaska, 99576  
Parker, Jim, Box 499, Sitka, Alaska, 99835  
Pederson, Paul, Box 686, Kodiak, Alaska, 99615  
Pennoyer, Steve, 212 International Airport Road, Anchorage, 99502  
Pirtle, Ralph, Box 669, Cordova, Alaska, 99574  
Reed, Rick, 188 So. Franklin, Juneau, Alaska, 99801  
Romey, Dan, Box 499, Sitka, Alaska, 99835

APPENDIX III (continued)

ADF&G: Alaska Department of Fish and Game

Roys, Robert S., Subport Building, Juneau, Alaska, 99801  
Shafford, Brian E., Box 686, Kodiak, Alaska, 99615  
Simon, Robert, Box 686, Kodiak, Alaska, 99615  
Solf, Dave, Box 669, Cordova, Alaska, 99574  
Tate, Paul, Petersburg, Alaska, 99833  
Valentine, John P., 2414 Tongass, Ketchikan, Alaska, 99901  
Williams, Fred T., Box 47, Glennallen, Alaska, 99588

CFS: Department of Environment, Canada Fisheries Service

Bird, Thomas D., 1155 Robson, Vancouver 5, B.C., Canada  
Chamberlin, T. W., 1155 Robson, Vancouver 5, B.C., Canada  
Fraser, Fred, 1155 Robson, Vancouver 5, B.C., Canada  
Harding, Dave, 1090 W. Ponder Street, Vancouver 5, B.C., Canada  
Hetherington, Eugene D., 506 W. Burnside Rd., Victoria, B.C., Canada  
Kearns, Roger, 1090 Ponder Street, Vancouver 5, B.C., Canada  
Meyer, Philip, 1155 Robson Street, Vancouver 5, B.C., Canada  
Webber, W. D., 1155 Robson Street, Vancouver 5, B.C., Canada  
Zyblut, E. R., 1155 Robson Street, Vancouver 5, B.C., Canada

FRBC: Fisheries Research Board of Canada

Bams, R. S., Biological Station, Nanaimo, B.C., Canada  
Narver, David W., Pacific Biological Station, Nanaimo, B.C., Canada  
Sibert, John, Biological Station, Nanaimo, B.C., Canada

FRI: Fisheries Research Institute

Cedarholm, C. J., University of Washington, Seattle, Washington, 98105  
Dell, Michael B., University of Washington, Seattle, Washington, 98105  
Hartt, Alan C., W-H 20, U. of Washington, Seattle, Washington, 98105  
Koski, K. V., U. of Washington, Seattle, Washington, 98105  
Schroder, Steve, U. of Washington, Seattle, Washington, 98105  
Stober, G. J., U. of Washington, Seattle, Washington, 98105  
Tyler, Richard W., U. of Washington, 260 Fish Center, Seattle, Wn., 98105

APPENDIX III (Continued)

GBS: Gateway Borough School District, Ketchikan, Alaska

Holden, Lucille, Ketchikan, Alaska, 99901

Jenkins, R. James, Ketchikan, Alaska, 99901

IPSFC: International Pacific Salmon Fisheries Commission

Chapman, Alan B., P.O. Box 30, New Westminster, B.C., Canada

NMFS: National Marine Fisheries Service

Bailey, Jack E., Box 155, Auke Bay, Alaska, 99821

Dewey, Robert D., Box 155, Auke Bay, Alaska, 99821

Drucker, Ben, Room 2552, Interior Bldg., Washington, D.C., 20235

Heard, William R., Box 155, Auke Bay, Alaska, 99821

Martin, Roy, Box 155, Auke Bay, Alaska, 99821

Mattson, Chet, Box 155, Auke Bay, Alaska, 99821

Thorsteinson, Fred, Box 1668, Juneau, Alaska, 99801

QRD: Quinault Resource Development

Allee, Brian J., Quinault Indian Reservation, Taholah, Washington, 98587

SJC: Sheldon Jackson College, Sitka, Alaska

Buck, Eugene H., Box 479, Sitka, Alaska, 99835

Metcalf, Phil, Box 479, Sitka, Alaska, 99835

Miller, Monte D., Box 943, Sitka, Alaska, 99835

Scheidi, David M., Box 213, Sitka, Alaska, 99835

TU: Tohoku University, Sendai, Japan

Sato, Ryuhei, Kita - 6 - Bancho, Sendai, Japan

USFS: United States Forest Service

Bergman, William P., Petersburg, Alaska, 99833

APPENDIX III (Continued)

USFS: United States Forest Service

Bishop, Dan, Box 1626, Juneau, Alaska, 99801  
Cooperrider, Bill, Box 1305, Juneau, Alaska, 99801  
Collins, Thomas M., Box 1628, Juneau, Alaska, 99801  
Billings, Richard F., Box 729, Petersburg, Alaska, 99833  
Howse, Norman, Chugach Nat'l. Forest, 121 W. Fireweed Lane,  
Anchorage, Alaska, 99502  
Olson, Sigurd, Box 1628, Juneau, Alaska, 99801  
Rentfro, Floyd L., USFS, Sitka, Alaska, 99835  
Sheridan, W.L., Box 1628, Juneau, Alaska, 99801  
Zylinski, Joseph, Box 1305, Juneau, Alaska, 99801

UA: University of Alaska, Fairbanks

Van Hyning, Jack M., University of Alaska, College, Alaska, 99701

WDF: Washington Department of Fisheries

Heiser, David W., 504 Custer Way, Tumwater, Washington, 98504  
Johnson, Ray, Room 115, General Admin. Bldg., Olympia, Washington, 98501

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